RECLAMATION
Managing Water in the West

Draft Environmental Impact Statement

Navajo Generating Station-Kayenta Mine Complex Project

Volume 1 – Title page through Section 3.7

The U.S. Department of the Interior protects America’s natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

United States Department of the Interior

BUREAU OF RECLAMATION
Lower Colorado Region
Phoenix Area Office
6150 West Thunderbird Road
Glendale, AZ 85306-4001

IN REPLY REFER TO:
PXAO-1500
ENV-6.00

Sept. 23, 2016

MEMORANDUM

To: All Interested Persons, Organizations, and Agencies

From: Leslie A. Meyers
Area Manager

Leslie A. Meyers

Subject: Notice of Availability of the Draft Environmental Impact Statement (EIS) for Public Review and Comment, and Schedule of Public Meetings, for the Navajo Generating Station–Kayenta Mine Complex (NGS-KMC) Project (Project) (Action by November 29, 2016)

The Bureau of Reclamation is issuing a *Federal Register* Notice of Availability of the Draft EIS on the proposed NGS-KMC Project on September 30, 2016. The Proposed Action in the EIS would provide Federal approvals and/or decisions necessary to continue the operation and maintenance of the NGS and associated facilities, the proposed Kayenta Mine Complex, and existing transmission systems for another 25 years, from December 23, 2019, through December 22, 2044, plus decommissioning.

The public review and comment period for the Draft EIS will be from September 30, 2016, through November 29, 2016. Comments received during the public review and comment period will be considered before the EIS is finalized and the Secretary of the Interior makes a decision about the Proposed Action. Public meetings are scheduled to occur from October 24, 2016, through November 4, 2016, (details of these meetings are provided later in this memorandum). This copy of the Draft EIS is included for your information and use.

The Draft EIS also is available for review or download on the Project website: http://www.NGSKMC-EIS.net. Additional information, including supplemental materials will be available on the project web site, as well.

A hard copy of the Draft EIS is available for public review and inspection at the following locations:

- Bureau of Reclamation, Phoenix Area Office, 6150 West Thunderbird Road, Glendale, Arizona.
- Natural Resources Library, U.S. Department of the Interior, 1849 C Street NW, Main Interior Building, Washington, DC.
- Bureau of Indian Affairs, Navajo Regional Office, 301 West Hill Street, Gallup, New Mexico.
- Office of Surface Mining and Reclamation Enforcement, Western Regional Office, 1999 Broadway Street, Suite 3320, Denver, Colorado.
- Glen Canyon National Recreation Area Headquarters, 691 Scenic View Road, Page, Arizona.

- Casa Grande Public Library, 449 North Drylake Street, Casa Grande, Arizona.
- Hopi Tribal Headquarters, Main Lobby, 123 Main Street, Kykotsmovi, Arizona.
- Navajo Nation Library, Highway 264 and Postal Loop Road, Window Rock, Arizona.
- LeChee Chapter House, 5 miles south of Page off of Coppermine Road, LeChee, Arizona.
- Tuba City Chapter House, 220 South Main Street, Tuba City, Arizona.
- Shonto Chapter House, East Navajo Route 221, Shonto, Arizona.
- Kayenta Chapter House, Highway 163, Kayenta, Arizona.
- Forest Lake Chapter House, 17 miles north of Pinon on Navajo Route 41, Pinon, Arizona.

Reclamation is holding 11 open-house meetings to give the public an opportunity to ask questions about the Draft EIS and provide your comments on what you think is missing from, or not properly evaluated in, the EIS. Members of the public may arrive at any time during each open-house meeting; there will be an informal presentation one-half hour after the meeting begins. Project team members will be available to provide information and answer questions about the Draft EIS. Written comments will be accepted at the meetings, and court reporters will be present at all meetings to record oral comments. Navajo and Hopi interpreters will be present at the open-house meetings as noted. The open-house meeting schedule is as follows:

1. Monday, October 24, 2016, 10 a.m. to 1 p.m., Burton Barr Central Library, Pulliam Auditorium, 1221 North Central Avenue, Phoenix, Arizona.
2. Monday, October 24, 2016, 5 p.m. to 8 p.m., Dorothy Powell Senior Adult Center, Dining Room, 405 East Sixth Street, Casa Grande, Arizona.
3. Tuesday, October 25, 2016, 4 p.m. to 7 p.m., Page Community Center, Cafeteria, 699 South Navajo Drive, Page, Arizona. (Navajo interpreters present).
4. Wednesday, October 26, 2016, 9 a.m. to 12 p.m., LeChee Chapter House, 5 miles south of Page off of Coppermine Road, LeChee, Arizona (Navajo interpreters present).
5. Wednesday, October 26, 2016, 4 p.m. to 7 p.m., Tuba City Chapter House, 220 South Main Street, Tuba City, Arizona (Hopi and Navajo interpreters present).
6. Thursday, October 27, 2016, 10 a.m. to 1 p.m., Shonto Chapter House, East Navajo Route 221, Shonto, Arizona (Navajo interpreters present).
7. Tuesday, November 1, 2016, 4 p.m. to 7 p.m., Monument Valley High School, Cafeteria, Highway 163 and Monument Valley Boulevard, Kayenta, Arizona (Navajo interpreters present).
8. Wednesday, November 2, 2016, 10 a.m. to 1 p.m., Tewa Community Center, Multipurpose Room, Highway 264 at Milepost 392.8, Polacca, Arizona (Hopi and Navajo interpreters present).
9. Wednesday, November 2, 2016, 4 p.m. to 7 p.m., Hopi Day School, Gym, ¼ mile east of the Village Store on Main Street, Kykotsmovi, Arizona (Hopi and Navajo interpreters present).

10. Thursday, November 3, 2016, 10 a.m. to 1 p.m., Forest Lake Chapter House, 17 miles north of Pinon on Navajo Route 41, Pinon, Arizona (Navajo interpreters present).
11. Friday, November 4, 2016, 10 a.m. to 1 p.m., Navajo Nation Museum, Conference Room, Highway 264 and Postal Loop Road, Window Rock, Arizona (Navajo interpreters present).

If special assistance is required at a public meeting, please contact Ms. Tania Fragomeno at 858-926-4022, or email your assistance needs to NGSKMC-EIS@usbr.gov, along with your name and telephone number. Please indicate your needs at least two (2) weeks in advance of the meeting to enable Reclamation to secure the needed services. The requestor will be notified if a request cannot be honored. The public is encouraged to submit comments by the deadline of November 29, 2016. Regardless of whether you are able to participate in the open-house meetings, you may send written comments via postal mail, hand delivery, or courier to:

NGS-KMC Project Manager, PXAO-1500
Bureau of Reclamation, Phoenix Area Office
6150 West Thunderbird Road
Glendale, AZ 85306-4001

You also may fax your comments to 623-773-6483 or email your written comments to NGSKMC-EIS@usbr.gov. To ensure comments are considered in the preparation of the Final EIS, they must be postmarked by the end of the comment period on November 29, 2016.

Before including your address, phone number, email address, or other personal identifying information in your comment, you should be aware that your entire comment – including your personal identifying information – may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

For more information regarding the EIS, please visit the Project website at http://www.NGSKMC-EIS.net, or call Ms. Sandra Eto, at 623-773-6254.

Attachment

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DRAFT ENVIRONMENTAL IMPACT STATEMENT
NAVAJO GENERATING STATION-KAYENTA MINE COMPLEX PROJECT

Lead Agency: Department of the Interior, Bureau of Reclamation

Cooperating Agencies: Department of the Interior
- Bureau of Indian Affairs
- Office of Surface Mining Reclamation and Enforcement
- Bureau of Land Management
- National Park Service
- U.S. Fish and Wildlife Service

U.S. Environmental Protection Agency
U.S. Department of Agriculture, Forest Service
Navajo Nation
Hopi Tribe
Gila River Indian Community
Pueblo of Zuni
Arizona Game and Fish Department
Central Arizona Water Conservation District

For further information regarding this Draft Environmental Impact Statement, visit http://www.ngskmc-eis.net or contact:

Ms. Sandra Eto
Bureau of Reclamation
6150 W. Thunderbird Road
Glendale, AZ 85306-4001
ngskmc-eis@usbr.gov
(623) 773-6254

Comments should be received by November 29, 2016

Filing Date: September 23, 2016

ABSTRACT

The Navajo Generating Station (NGS) is an existing 2,250-megawatt (MW) coal-fired power plant located on leased Navajo Nation tribal trust lands about 5 miles east of Page, Arizona. NGS provides baseload power to over 1 million customers in Arizona, California, and Nevada. NGS also provides over 90 percent of the power used by the Central Arizona Project (CAP), a federal Bureau of Reclamation (Reclamation) project that delivers approximately 1.5 million acre-feet annually of Colorado River water from a diversion point in Lake Havasu near Parker, Arizona, to tribal, agricultural, municipal, and industrial water users in Maricopa, Pinal, and Pima counties, Arizona. Reclamation is authorized to sell its share of NGS power, which is in excess to the needs of the CAP, at market rates. The revenues from the sale of this surplus power are deposited into the Lower Colorado River Basin Development Fund (Development Fund). The Development Fund is used to assist in the annual repayment of construction costs for the CAP, and for the payment of fixed operation, maintenance, and replacement charges associated with the delivery of CAP water to Arizona Native American tribes, as well as other statutory purposes.

The coal supply for the NGS is delivered from Kayenta Mine, located about 78 miles southeast of NGS. The Kayenta Mine is the sole commercial supplier of coal used by the NGS and NGS is the sole commercial customer of coal produced at the Kayenta Mine. The Kayenta Mine is located on Navajo and Hopi trust lands, on which three contiguous mining leases have been granted to Peabody Western Coal Company.

Together the Navajo lease for the NGS and its associated facilities and the Navajo and Hopi coal mining leases have provided both the Navajo and Hopi tribes with substantial revenues from lease and coal royalties that support the Navajo and Hopi governments.

This Draft Environmental Impact Statement (EIS) evaluates the environmental impacts that would result from the continued operation and maintenance of the NGS and associated facilities, the proposed Kayenta Mine Complex (KMC), and existing transmission systems, from December 23, 2019 through December 22, 2044, plus decommissioning of the facilities and reclamation of the land (the Proposed Action). Three action alternatives are evaluated in the EIS. Each action alternative would provide for partial replacement of the federal portion of NGS power, but would require continued operation of the NGS and proposed KMC to supply the remaining power required to run the CAP pumps and provide excess power for sale at market rates to generate funds that would be deposited to the Development Fund. A No Action Alternative also is evaluated in which approvals would not be granted. NGS decommissioning activities would begin in 2018 with effective shutdown of the power plant occurring by the end of 2019. Coal mine reclamation is assumed to begin in 2019 and would continue for 10 to 15 years until final bond release.

Additional project-related materials are available for viewing or download at http://www.NGSKMC-EIS.net/.

Executive Summary

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1 # Acronyms and Abbreviations

1969 Lease	Navajo Project Indenture of Lease
BART	Best Available Retrofit Technology
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BM&LP Railroad	Black Mesa & Lake Powell Railroad
BO	Biological Opinion
CAP	Central Arizona Project
CAWCD	Central Arizona Water Conservation District
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO_2	carbon dioxide
Co-tenants	Salt River Project, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company
Development Fund	Lower Colorado River Basin Development Fund
EIS	Environmental Impact Statement
ERA	Ecological Risk Assessment
ESA	Endangered Species Act of 1973
HHRA	Human Health Risk Assessment
km	kilometer
KMC	Kayenta Mine Complex
kV	kilovolt
kW	kilowatt
MW	megawatt
N-Aquifer	Navajo Aquifer
NEPA	National Environmental Policy Act of 1969, as amended
NGS	Navajo Generating Station
NGS Participants	U.S. (Reclamation), Salt River Project, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company
NHPA	National Historic Preservation Act
NNEPA	Navajo Nation Environmental Protection Agency
NO_2	nitrogen dioxide
NO_X	nitrogen oxide
OSMRE	Office of Surface Mining Reclamation and Enforcement
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter of 10 microns or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 microns or less
PFR	Partial Federal Replacement
PWCC	Peabody Western Coal Company
Reclamation	U.S. Bureau of Reclamation
ROW	Right-of-way
SO_2	sulfur dioxide
SRP	Salt River Project Agricultural Improvement and Power District

STS	Southern Transmission System
U.S.	United States
USC	United States Code
USEPA	U.S. Environmental Protection Agency
WTS	Western Transmission System

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ES1.0 Executive Summary

ES1.1 Introduction

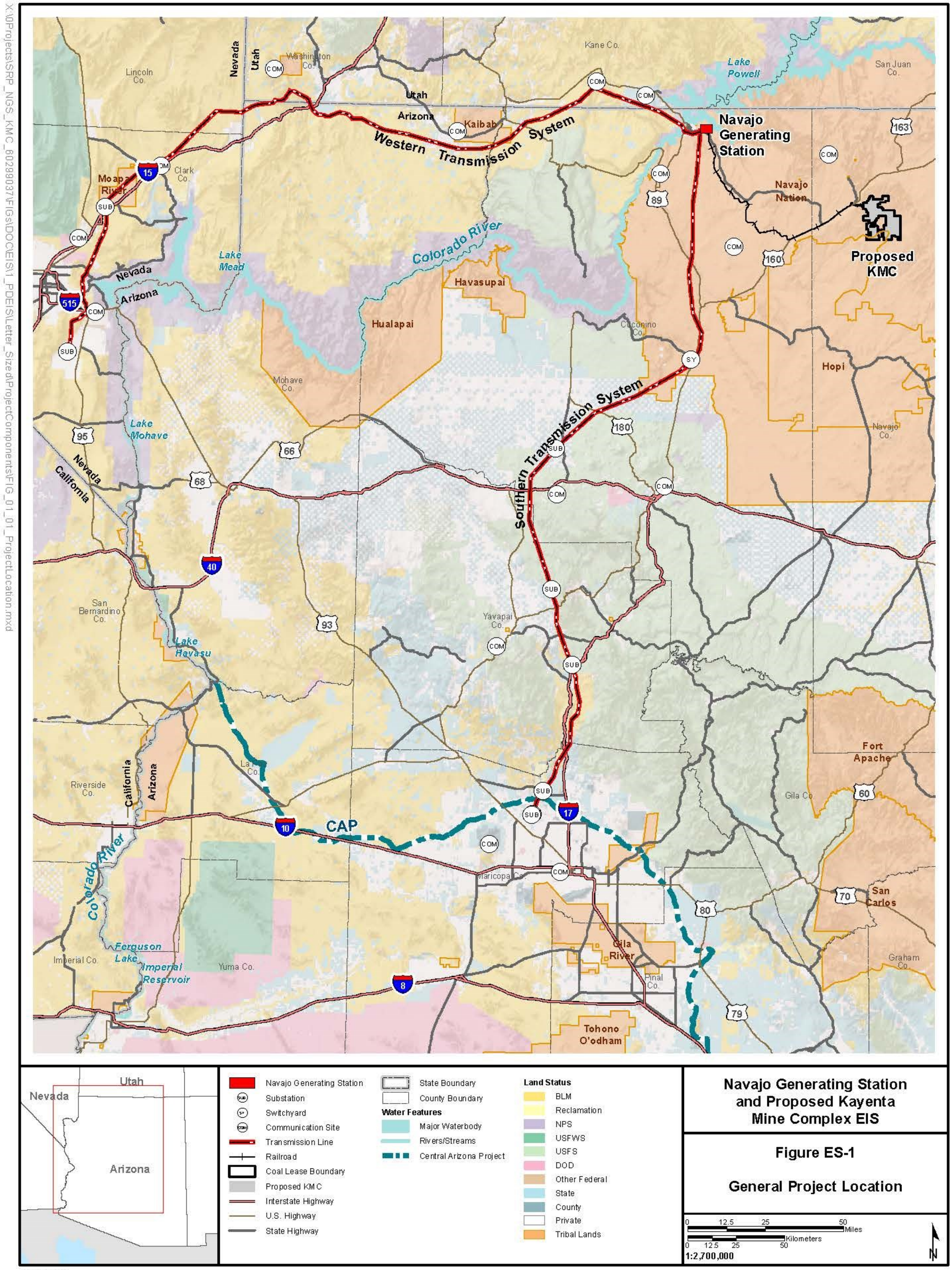
The Navajo Generating Station (NGS) is an existing 2,250-megawatt (MW) coal-fired power plant located on leased Navajo Nation tribal trust lands approximately 5 miles east of Page, Arizona. NGS provides baseload power to over 1 million customers in Arizona, California, and Nevada. NGS also provides over 90 percent of the power used by the Central Arizona Project (CAP), a federal project that delivers approximately 1.5 million acre-feet annually of Colorado River water from a diversion point in Lake Havasu near Parker, Arizona, to tribal, agricultural, municipal, and industrial water users in Maricopa, Pinal and Pima counties, Arizona. The current NGS Participants include the NGS Co-tenants (Salt River Project Agricultural Improvement and Power District (SRP), which also is the operator of NGS; NV Energy; and Tucson Electric Power Company), and the United States. Power generated by NGS is transmitted to points of delivery by the Western Transmission System (WTS) and Southern Transmission System (STS) and their associated substations and communication sites.

The coal supply for the NGS is delivered from Peabody Western Coal Company's (PWCC) Kayenta Mine, located approximately 78 miles southeast of NGS. The Kayenta Mine is the sole commercial supplier of coal used by the NGS, and NGS is the sole commercial customer of coal produced at the Kayenta Mine. The Kayenta Mine is located on the Black Mesa and on Navajo and Hopi trust lands, where PWCC has been granted three contiguous mining leases that provide PWCC the right to produce up to a total of 670 million tons of coal (**Figure ES-1**). Under the Proposed Action, facilities on the former Black Mesa Mine currently being used to support the Kayenta Mine operations would be combined with the existing Kayenta Mine to create the proposed Kayenta Mine Complex (KMC); mining would not be authorized anywhere in the former Black Mesa Mine area.

The terms of the Navajo Project Indenture of Lease for Units 1, 2, and 3 (1969 Lease) for NGS and its associated facilities and the Navajo and Hopi coal mining leases have provided both tribes with substantial revenues from lease and coal royalties, which support the Navajo and Hopi governments.

ES1.2 Public Involvement/Scoping

Formal Public Scoping was initiated when a Notice of Intent to prepare an Environmental Impact Statement (EIS) was published in the *Federal Register* on May 16, 2014; Public Scoping closed on August 31, 2014. Ten public scoping open house meetings were held June 10-June 20, 2014, in the following Arizona locations: Window Rock, Forest Lake, Kayenta, Shonto, LeChee, and Tuba City on the Navajo Reservation; Kykotsmovi on the Hopi Reservation; and Page, Phoenix, and Marana. An additional scoping open house meeting was held on Third Mesa of the Hopi Reservation on August 14, 2014, and two community outreach meetings also were held on the Hopi First and Second Mesas on August 13, 2014. At the request of residents living within the PWCC mine leasehold, two listening sessions were held at the PWCC Human Resources Center on July 16 and August 28, 2015. The residents provided input on cultural resources and other issues related to the Proposed Action.



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure ES-1

General Project Location

ES1.3 Purpose and Need for the Proposed Action

The Secretary of the Interior (Secretary) proposes to approve the federal actions, which would enable continued involvement by the United States (U.S.) in the NGS beyond December 22, 2019, when the current lease between the NGS Co-tenants and the Navajo Nation is set to expire. There are a number of federal approvals and actions associated with the Proposed Action under the Secretary's authority (**Table ES-1**). The following are the major Secretarial approvals described in detail in the Environmental Impact Statement (EIS):

- As an NGS Participant, the U.S. Bureau of Reclamation (Reclamation) needs to respond to the impending expiration of the initial term of the 1969 Lease, grants of right-of-way (ROW) and easements, and other agreements needed for the continued operation of NGS. Reclamation's purpose for the Proposed Action is to secure, after 2019, a continuously available and reliable source of power and energy to operate the CAP pumps, which would be competitively priced with NGS and could be sold as surplus power, the proceeds of which would be deposited in the Lower Colorado River Basin Development Fund (Development Fund). Development Fund revenues are used to assist in repayment of CAP construction costs, and for the payment of fixed operation, maintenance, and replacement charges associated with the delivery of CAP water to Arizona Native American tribes and other statutory purposes.
- The Office of Surface Mining Reclamation and Enforcement (OSMRE) is responsible for carrying out the requirements of the Surface Mining Control and Reclamation Act (SMCRA) in cooperation with states and tribes. As the regulatory authority on Indian lands, OSMRE (Western Region) is responsible for ensuring that the operation of the proposed Kayenta Mine Complex (KMC) permit area would be in accordance with all SMCRA requirements, including all applicable environmental performance and reclamation standards. Accordingly, OSMRE needs to respond to PWCC's SMCRA Kayenta Mine permit revision application and proposed Life-of-Mine Plan and determine whether to approve, approve with special conditions, or disapprove the application in accordance with the requirements of SMCRA. OSMRE's purpose for the Proposed Action is to implement the environmental protections, reclamation standards, and other permitting requirements under SMCRA, while balancing the U.S.' need for continued domestic coal production with protection of the environment (see 30 United States Code [USC] Section 1202).
- The Bureau of Indian Affairs (BIA)-Navajo Region must decide, consistent with the requirements of 25 USC Section 415(a) and 25 Code of Federal Regulations (CFR) Part 169, and subject to the consent of the Navajo Nation, whether or not to approve: 1) the NGS Lease Amendment No. 1 (or a leasing agreement with the Navajo Nation having similar terms as the 1969 Lease and Lease Amendment No. 1) and 2) other grants of ROW issuances, amendments, or renewal(s) that would allow for the continued operation of the NGS and its associated facilities on Navajo Tribal trust land through December 22, 2044. BIA also must approve the proposed relocation of portions of Navajo Route 41 within the proposed KMC permit area on Navajo and Hopi surface lands.
- Each of the federal decisions at issue must be consistent with federal Indian policies including, but not limited to, a preference for tribal self-determination and promotion of tribal economic development for all tribes affected by these federal decisions. In addition, the federal government has a trust responsibility to protect and maintain rights reserved by, or granted to, Indian tribes and individuals by treaties, statutes, and executive orders.

Table ES-1 Preliminary List of Federal Actions for the NGS-KMC Project

Entity and Role in EIS	Approval Action – NGS and Associated Facilities, WTS, and STS	Approval Action – Proposed KMC
Federal Entities		
Reclamation Role: Lead federal agency for purposes of complying with the National Environmental Policy Act (NEPA), Section 7 of the Endangered Species Act (ESA), and Section 106 of the National Historic Preservation Act, Ensure adequate coordination with the key cooperating agencies, other cooperating agencies, and affected tribes as appropriate. Ensure EIS complies with the Council on Environmental Quality, U.S. Department of the Interior, and Reclamation NEPA requirements; review and approve project mitigation; ensure all information is adequate to issue a Record of Decision based on the Final EIS analysis. Conduct Government-to-Government consultations with affected tribes.	Approve or consent to contracts and other arrangements to extend the NGS Project operations through 2044, including but not limited to: • Amendment No. 1 to the Indenture of Lease between Navajo Nation and NGS Participants (or a leasing agreement with the Navajo Nation having similar terms as the 1969 Lease and Lease Amendment No. 1); • Land grants, easements, and ROWs; • Revisions to or new Co-Tenancy Agreement and other Navajo Project Agreements among the NGS Participants; and • Extension of the Coal Supply Agreement. Develop and approve terms of a renewal contract for water service from Lake Powell for operations through 2044 pursuant to Article 2 of the January 17, 1969, Water Service Contract; 1902 Reclamation Act (32 Statute 388) as amended; and 1956 Colorado River Storage Project Act Boulder Canyon (70 Statute 105), as amended. Issue a new license for the railroad crossing under the Glen Canyon Shiprock 230-kilovolt transmission line, Contract No. 14-06-400-5882 pursuant to the 1902 Reclamation Act (32 Statute 388), as amended. Issue new easement for a portion of the WTS pursuant to the 1902 Reclamation Act (32 Statute 388), as amended. Approve and provide funding in proportion to its Participant share in NGS of the actions required for the operation of NGS, WTS, and STS according to the project agreements and for eventual decommissioning.	Approve coal supply agreement between PWCC and NGS Co-tenants.

Table ES-1 Preliminary List of Federal Actions for the NGS-KMC Project

Entity and Role in EIS	Approval Action – NGS and Associated Facilities, WTS, and STS	Approval Action – Proposed KMC
OSMRE – Western Region Role: Act as key cooperating agency per Memorandum of Understanding among Reclamation, OSMRE, BIA, SRP, and PWCC. Review EIS regarding compliance with OSMRE requirements; ensure all information is adequate to issue a Record of Decision based on the Final EIS analysis. Participate in government-to-government consultations.	None	Approve a permit revision for: • Changes in the proposed KMC Life-of-Mine Plan; • Relocation of a public road; and • Adjustment of a permit boundary pursuant to Surface Mining Control and Reclamation Act to include existing support facilities (30 USC Section 1201 et seq.). Consult on potential impacts to cultural resources. Participate in ESA Section 7 consultation.
BIA – Navajo Region Role: Act as key cooperating agency per Memorandum of Understanding among Reclamation, OSMRE, BIA, SRP, and PWCC. Review EIS regarding compliance with BIA requirements; ensure all information is adequate to issue a Record of Decision based on the Final EIS analysis. Participate in government-to-government consultations.	Approve the NGS Project Lease Amendment No. 1 (or a leasing agreement with the Navajo Nation having similar terms as the 1969 Lease and Lease Amendment No. 1) pursuant to 25 USC Section 415(a) and 25 CFR Part 162. Approve renewed, amended, or new 323 Grants of ROW and easements for the NGS Project on Navajo Nation Indian Lands pursuant to 25 USC Section 323 and 25 CFR Part 169, including but not limited to: • Plant Site and associated facilities; • Railroad; • Coal Conveyor; • WTS; • STS; • Communication Sites; and • Moenkopi Switchyard. Approve actions by the Navajo Nation to take on an ownership interest in NGS pursuant to provisions contained in the Lease Amendment No.1 (or a leasing agreement with the Navajo Nation having similar terms as the 1969 Lease and Lease Amendment No. 1), should the Navajo Nation choose to do so. Consult on potential impacts to cultural resources. Participate in ESA Section 7 consultation.	Approve realignment of Navajo Route 41 pursuant to 30 CFR Part 761.14(b). Renew or issue new grants of ROW and easements for the NGS-KMC Project on tribal lands.

Table ES-1 Preliminary List of Federal Actions for the NGS-KMC Project

Entity and Role in EIS	Approval Action – NGS and Associated Facilities, WTS, and STS	Approval Action – Proposed KMC
BIA – Western Region Role: Act as cooperating agency per Memorandum of Understanding between Reclamation and BIA – Western Region. Participate in government-to-government consultations.	Approve or disapprove Pipe Spring communication site 323 Grant pursuant to 25 USC Section 323 and 25 CFR Part 169. Consult on potential impacts to cultural resources	
BIA Western Region – Hopi Agency Role: Review EIS regarding compliance with BIA requirements; ensure all information is adequate to issue a Record of Decision based on the Final EIS analysis.	None	Approve realignment of Navajo Route 41 pursuant to 30 CFR Part 761.14(b).
Bureau of Land Management (BLM) Role: Act as cooperating agency per Memorandum of Understanding between Reclamation and BLM.	Issue new Federal Land Policy and Management Act ROW grants for the STS and WTS across jurisdictional public lands in Arizona, Utah, and Nevada pursuant to Title V. Ensure use is administered consistent with Public Law 96-491 for segment through Moapa Reservation. Consult on potential impacts to cultural resources. Participate in ESA Section 7 consultation.	Approve changes to the proposed KMC Resource Recovery and Protection Plan (mining plan) pursuant to 25 CFR Part 216; 43 CFR Part 3480.
U.S. Army Corps of Engineers Role: Review the EIS for compliance with Clean Water Act regulations, if applicable.	None	As applicable, approve Section 404 permit modifications and a revision for the proposed KMC pursuant to the Clean Water Act 33 USC Section 1342; 33 CFR Parts 320, 323, 325.
U.S. Fish and Wildlife Service Role: Act as cooperating agency per Memorandum of Understanding between Reclamation and U.S. Fish and Wildlife Service.	As applicable, prepare and issue a Biological Opinion, pursuant to Section 7 of the ESA (16 USC Section 1531 et seq.). Ensure compliance with the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act.	As applicable, prepare and issue a Biological Opinion, pursuant to Section 7 of the ESA (16 USC Section 1531 et seq.). Ensure compliance with the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act.

Table ES-1 Preliminary List of Federal Actions for the NGS-KMC Project

Entity and Role in EIS	Approval Action – NGS and Associated Facilities, WTS, and STS	Approval Action – Proposed KMC
National Park Service Role: Act as cooperating agency per Memorandum of Understanding between Reclamation and National Park Service.	Renew or issue a new ROW permit to cover a portion of the underground water intake (tunnel) system that supplies water to NGS. The renewed or newly issued permit would replace ROW Permit No. RW GLCA-06-002, granted pursuant to 16 USC Section 79 and expiring in 2032, to cover the period until 2044. Renew a ROW for a portion of the WTS on the Glen Canyon National Recreational Area pursuant to 16 USC Section 5 and 36 CFR Part 14. Consult on potential impacts to cultural resources. Participate in ESA Section 7 consultation.	None
U.S. Environmental Protection Agency (USEPA) Role: Act as cooperating agency per letter dated May 28, 2014. Review EIS for compliance with applicable federal environmental regulations.	USEPA has delegated the Clean Air Action's Title V operating permit program under 40 CFR Part 71 to the Navajo Nation Environmental Protection Agency (NNEPA). NNEPA issued the current Part 71 permit for the Kayenta Mine, and PWCC has submitted a renewal application to NNEPA. Final approval of Clean Air Act Title V, 40 CFR Part 71, operating permit renewal currently is pending with NNEPA. Action on this permit renewal is anticipated to occur prior to 2020.	As applicable, approve National Pollution Discharge Elimination System permit modifications and a revision for the proposed KMC pursuant to the Clean Water Act (33 USC Section 1342); 40 CFR Part 124.9. If needed, approve Nationwide Stormwater Discharge Permit. USEPA has delegated the Clean Air Act's Title V operating permit program under 40 CFR Part 71 to the NNEPA. NNEPA issued the current Part 71 permit for the Kayenta Mine, and PWCC has submitted a renewal application to NNEPA.
U.S. Forest Service Role: Act as cooperating agency per Memorandum of Understanding between Reclamation and U.S. Forest Service.	Renew ROWs across the Kaibab and Prescott National Forests in Arizona originally granted pursuant to the Act of March 4, 1911 (36 Statute 1253, as amended by Public Law 307, 66 Statute 95). Consult on potential impacts to cultural resources.	None

Table ES-1 Preliminary List of Federal Actions for the NGS-KMC Project

Entity and Role in EIS	Approval Action – NGS and Associated Facilities, WTS, and STS	Approval Action – Proposed KMC
Non-federal Entities		
Navajo Nation Role: Act as cooperating agency per Memorandum of Understanding between Reclamation and the Navajo Nation. Participate in government-to-government consultations.	Review and approve the Clean Air Act Title V, 40 CFR Part 71, operating permit renewal application. The Navajo Nation will periodically (every 5 years) review and issue the permit. Government-to-government consultation with Reclamation on Section 7 of the ESA and special status species. Decide whether to execute the option to take on an ownership interest in NGS pursuant to provisions contained in the Lease Amendment No. 1. If needed, and as an alternative to Lease Amendment No. 1, approval of a new lease agreement among the Navajo Nation and the continuing NGS owners having similar terms as Lease Amendment No. 1. Consult on potential impacts to cultural resources.	Consult on potential impacts to cultural resources. Government-to-government consultation on Section 7 of the ESA and Special Status Species. Consult by performing a technical review of the Life-of-Mine application. Approve or disapprove Clean Water Act Section 401 water quality certifications, if needed. On behalf of USEPA, issue renewal of KMC's federal Title V operating permit, if needed.
Hopi Tribe Role: Review the EIS and provide technical information. Participate in government-to-government consultations.	Consult on potential impacts to cultural resources.	Consult on potential impacts to cultural resources. Government-to-government consultation on Section 7 of the ESA and Special Status Species. Consult by performing a technical review of the Life-of-Mine application. Approve or disapprove Clean Water Act Section 401 water quality certifications, if needed.
Gila River Indian Community Role: Act as cooperating agency per Memorandum of Understanding between Reclamation and Gila River Indian Community.	None	None
Pueblo of Zuni Role: Review the EIS and provide technical information. Participate in government-to-government consultations.	Consult on potential impacts to cultural resources.	Consult on potential impacts to cultural resources. Government-to-government consultation on Section 7 of the ESA and Special Status Species.

Table ES-1 Preliminary List of Federal Actions for the NGS-KMC Project

Entity and Role in EIS	Approval Action – NGS and Associated Facilities, WTS, and STS	Approval Action – Proposed KMC
Central Arizona Water Conservation District Role: Act as cooperating agency per Memorandum of Understanding between Reclamation and the Central Arizona Water Conservation District.	None	None
Arizona Game and Fish Department Role: Act as cooperating agency per Memorandum of Understanding between Reclamation and the Arizona Game and Fish Department.	None	None

ES1.4 Development and Description of Alternatives

Public comments received during the scoping period expressed strong support for Reclamation reducing its share of carbon emissions associated with supplying power to the CAP. Numerous commenters supported the study of potential EIS alternatives focused on replacing all or a portion of the federal share of NGS power with power from sources that would reduce atmospheric emissions over those of the Proposed Action. A majority of scoping comments related to alternatives to the Proposed Action advocated the use of renewable energy sources.

ES1.4.1 Alternatives Considered but Eliminated from Detailed Analysis in the EIS

Alternatives were eliminated from further consideration if they could not provide a continuously available and reliable source of power and energy to operate the CAP pumps, which would be competitively priced with NGS and could be sold as surplus power to generate revenues for deposit to the Development Fund.

The purpose and need for the Proposed Action focuses only on the federal share of power and energy from NGS; however, to ensure full consideration of all reasonable alternatives that could meet the purpose and need for the Proposed Action, Reclamation investigated the practicability of replacing NGS in its entirety, with power generation facilities that would emit less carbon than coal (i.e., lower emitting sources). Potential generation alternatives included retrofitting NGS to natural gas; hydropower; nuclear power; distributed power generation along the CAP system; biomass; and conservation. These potential alternatives were rejected because they would not meet the purpose and need for the Proposed Action due to infeasibility (retrofitting NGS to natural gas, distributed power generation along the CAP system, biomass, conservation) or unavailability (hydropower, nuclear). No alternatives that replaced NGS in its entirety were carried forward.

Reclamation also explored replacing major elements associated with the existing NGS and proposed KMC, which could reduce the overall environmental impacts of the Proposed Action. The lack of any technical or environmental advantage associated with replacing these components and associated economic costs and/or environmental impacts resulted in no reasonable alternatives being carried forward that replaced existing major project elements.

Reclamation then considered alternatives that could replace the entire federal share of NGS (547 MW) and be sold as surplus power. To assist in this evaluation, the National Renewable Energy Laboratory, a part of the Department of Energy, conducted an analysis of wholesale electricity prices. This analysis encompassed historical pricing trends, time-of-day variations, and pricing patterns in the energy futures market (National Renewable Energy Laboratory 2015). Reclamation concluded the most cost effective total federal replacement alternative, a combined-cycle natural gas plant, could result in power generation costs that would be higher than the reasonably foreseeable market price of power; therefore, this alternative likely would not be able to generate surplus power revenues. Because total federal replacement of NGS would not be able to generate surplus power revenues for deposit to the Development Fund, this alternative was not carried forward.

ES1.4.2 Alternatives Evaluated in the EIS

Reclamation concluded that only a partial federal replacement (PFR) alternative, which would include continued operation of the NGS to provide a portion of the power needed to operate the CAP system and enable surplus power revenues to be generated, would fulfill the purpose of and need for the Proposed Action. Through the public scoping process, three central themes with respect to alternatives development became evident: 1) seek to minimize energy costs to the CAP; 2) explore renewable energy technology as an economically viable option; and 3) consider tribal socioeconomic impacts. Development of the three PFR alternatives evaluated in the EIS attempted to address these three themes.

ES1.4.2.1 NGS-KMC Project (Proposed Action)

Under the Proposed Action, NGS would be authorized to continue operating from December 23, 2019, through December 22, 2044 (2020-2044), plus decommissioning. Historical (through 2019) NGS-related operation, maintenance, and repair/replacement practices would be expected to continue during this additional 25-year operational period. NGS would continue to supply the federal share of NGS power and energy (approximately 547 MW) that would be used to operate the CAP pumps and be sold as surplus energy to generate funds for deposit to the Development Fund. Adjustments would be made as appropriate to comply with changing environmental regulations, as well as new applicable regulations that become effective during the 2020-2044 timeframe.

The most significant of these new regulations is the Federal Implementation Plan related to the Clean Air Act Regional Haze Rule, which was promulgated August 8, 2014, by the USEPA. Implementation of these regulations at NGS depends upon final NGS ownership arrangements. The timing and manner of implementation of the Federal Implementation Plan would be affected by how NV Energy exits from NGS generation ownership and participation, and whether or not it sells its shares to a third-party. It also is unclear if and when the Navajo Nation would exercise its option to become a Co-tenant of NGS with an entitlement of up to 170 MW under Lease Amendment No. 1 (or a leasing agreement with the Navajo Nation having similar terms as the 1969 Lease and Lease Amendment No. 1). As a result of these currently unknown ownership arrangements, there are a number of operating scenarios that could occur under the Proposed Action. The main difference among them is whether the plant would be operated with 3 or 2 units to meet owner generation entitlements. This decision is not a choice to be made by the Secretary; rather, it will be dictated by generation requirements of the final ownership arrangements.

For purposes of the EIS, emissions from the Proposed Action were calculated for a range of operations that could be implemented based on both 3-Unit Operation and 2-Unit Operation. The 3-Unit Operation would continue historical operations; however, in 2026-2027, selective catalytic reduction would be installed on all three units. Under the 2-Unit Operation, one of the 750-MW units would be decommissioned at the end of 2019. The remaining two units would continue to operate and in 2029-

2030, selective catalytic reduction would be installed. The operating units with selective catalytic reduction installed would then continue to operate until 2044, when the plant would be decommissioned and shut down. Either operation would result in compliance with the Federal Implementation Plan by the end of the 25-year period. The NGS and its associated facilities would be decommissioned consistent with the terms of the 1969 Lease and Lease Amendment No. 1 (or a leasing agreement with the Navajo Nation having similar terms as the 1969 Lease and Lease Amendment No. 1).

Coal mining operations under the Proposed Action would mirror the NGS operations ultimately implemented. Under the 3-Unit Operation, mining operations and the amount of coal mined and delivered to NGS would continue at a rate of approximately 8.1 million tons per year. Under the 2-Unit Operation, the amount of coal mined and delivered to NGS would be approximately 5.5 million tons per year; all other mining operations would remain essentially the same as under the 3-Unit Operation, including the amount of water pumped from the Navajo Aquifer (N-Aquifer). Final land reclamation would begin in 2044 and be completed within 10 to 15 years.

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

As part of the Proposed Action, conservation measures that are agreed upon with the U.S. Fish and Wildlife Service would be implemented to ensure that impacts from the continued operations of NGS and the proposed KMC would not jeopardize the continued existence of federally listed species or adversely modify designated critical habitat.

ES1.4.2.2 Natural Gas Partial Federal Replacement Alternative

Under this alternative, a portion of the federal share of NGS power and energy would be replaced by natural gas, assumed to be generated by an existing combined cycle plant and purchased through a Power Purchase Agreement. For purposes of this EIS, it was assumed that between 100 MW and 250 MW would be replaced. The natural gas replacement power would be supplied on a 24-hour, 7 days a week basis. NGS would curtail its output by the corresponding amount and would continue production to generate the Co-tenants' entitlements and the remaining amount of the federal share, including power that is surplus to CAP operational needs. This surplus power would be sold at market rates to produce revenue for deposit to the Development Fund. This alternative analysis assumes utilization of existing natural gas resources to reduce net emissions and minimize resulting cost increases, while maintaining the availability and value of surplus energy from NGS at approximately the same quantities as under the Proposed Action.

ES1.4.2.3 Renewable Partial Federal Replacement Alternative

Under this alternative, a portion of the federal share of NGS power and energy would be replaced by power generated by renewable resources that would be purchased through a Power Purchase Agreement. It was assumed that between 100 MW and 250 MW would be replaced. The renewable energy would be supplied to the CAP during a defined time period. For purposes of this EIS, it was assumed that this would be 14 hours per day, 7 days a week. The Power Purchase Agreement would require that a non-renewable source of power be included for the 14-hour period to maintain reliability during short-term fluctuations in output (e.g., cloud cover). NGS would curtail its output by the corresponding amount and would continue production to generate the Co-tenants' entitlements and the remaining amount of the federal share, including surplus power that is sold at market rates to produce revenue for deposit to the Development Fund. This alternative analysis assumes utilization of existing renewable energy resources to reduce net emissions, while maintaining the availability and value of surplus energy from NGS at approximately the same quantities as under the Proposed Action.

ES1.4.2.4 Tribal Partial Federal Replacement Alternative

Under this alternative, a portion of the federal share of NGS power and energy would be replaced by power purchased through a Power Purchase Agreement. That power would be generated by a new renewable energy facility constructed on NGS-affected tribal land. For purposes of this EIS, it was assumed that this would be a photovoltaic solar facility, and that energy from this facility would be dedicated to meet a portion of CAP demands (between 100 MW to 250 MW) during daylight hours (12 hours per day, 7 days a week), ramping up during the morning hours, leveling out during the middle of the day, and then ramping down during the evening. Similar to the Renewable PFR, the Tribal PFR would require that a non-renewable source of power be included for the defined period of delivery to maintain reliability during short-term fluctuations in output (e.g., cloud cover). NGS would curtail its output by the corresponding amount and would continue production to generate the Co-tenants' entitlements and the remaining amount of the federal share, including surplus power that is sold to produce revenue for the Development Fund. This alternative would reduce net emissions using renewable technology and provide an opportunity for NGS-affected tribes to develop photovoltaic solar capacity, while maintaining the availability and value of surplus energy from NGS at approximately the same quantities as under the Proposed Action. Federal action(s) associated with development of a photovoltaic solar facility on tribal land would necessitate compliance with the NEPA, ESA, and National Historic Preservation Act, as appropriate, before a Power Purchase Agreement would be authorized. If use of a ROW or intertie to a transmission line or substation is needed, required federal approval and additional compliance with federal environmental statutes (e.g., NEPA, ESA, and National Historic Preservation Act) would be obtained for construction of transmission-related infrastructure as a subsequent action.

ES1.4.2.5 No Action Alternative

Under the No Action Alternative, the 1969 Lease, associated ROWs, and other arrangements would not be extended past December 22, 2019. NGS decommissioning activities would be completed by the end of 2019. Reclamation of the coal mine and mining operations would begin in 2019 and would continue for 10 to 15 years until final bond release.

The NGS Co-tenants would need to obtain sufficient capacity and baseload energy to replace the amount lost due to the closure of NGS. Each Co-tenant would work independently to develop and secure its replacement resources. Current supply and demand projections for the region suggest that the predominant source of long-term replacement of baseload resources eventually would be the construction of new gas-fired, combined-cycle generation located at low elevations and near existing gas supply lines, transmission lines, water supplies, and the load areas of the Co-tenants. It is not possible to accurately predict the location, number, or size of the replacement generating resources because of the many variables that each utility would consider in its resource replacement strategy, including compliance and cost of environmental regulations such as the forthcoming ozone standards. A combined cycle gas-fired generating station typically would require a minimum of 4 years to over 6 years to plan, site, permit, and construct. In the interim, each utility would ensure sufficient baseload power resources for their customers through: (1) use of their existing generating resources, if available; (2) the acquisition of existing merchant generation capacity; (3) Power Purchase Agreements; or (4) some combination of such resources. The ability to defer the construction of new replacement resources by utilizing existing resources would be dependent on regional peak capacity and demand conditions. It may be the case that limited excess peak capacity would exist and the construction of new resources would be expedited to ensure grid reliability.

The NGS transmission system is an established part of the western U.S. transmission grid and supports reliability and delivery of power throughout the region, well beyond the power generated by the NGS. Therefore, under the No Action Alternative, one, several, or all of the land owners/managers of the transmission line ROWs and communication site leases likely would renew some portion of the facilities to keep the power grid performing as expected.

In the event that some or all of the transmission systems and communication site ROWs are not renewed, a lengthy study, permitting process, and construction of replacement facilities would need to occur before decommissioning is initiated due to the essential and integral nature of these facilities with the western U.S. transmission grid. An estimated 4,826 acres within and alongside the transmission system corridors could be temporarily disturbed if the entirety of the transmission systems and communication sites were decommissioned and removed.

Under the No Action Alternative, NGS power and energy no longer would be available to operate the CAP pumps. As system operator, the Central Arizona Water Conservation District (CAWCD) would continue to be responsible for obtaining the power necessary to deliver CAP water. CAWCD has indicated that it would develop a diversified energy portfolio to manage risk and moderate impacts from energy market volatility, if and when NGS is no longer available. CAWCD has further indicated its goal would be that no individual generation source or contractual supply would make up more than 15 to 20 percent of that portfolio (CAWCD 2013). Under this alternative, CAWCD would acquire just enough power to meet CAP pump loads. There would be no surplus power or energy that could be sold to create revenues for CAP repayment assistance or to benefit other purposes of the Development Fund.

Approximately 2.9 million MW hours of electricity is needed annually to meet CAP pumping requirements. That equates to an average hourly power requirement of approximately 350 MW, which CAWCD would meet through baseload resources. For purposes of this EIS, it was assumed that CAWCD would look to natural gas-fueled generation to meet its baseload power needs. Natural gas commonly is used as a peaking resource and could provide baseload generation for CAP. According to information supplied by USEPA in connection with its Clean Power Plan, the current capacity factor of natural gas located in Arizona is 27 percent. However, it appears that existing natural gas capacity is fully utilized in the summer months to meet Arizona's peak demands. It also is not clear how the closure of NGS would affect surplus natural gas capacity after 2019. Therefore, while there may be unused natural gas capacity that could supply a portion of CAP's needs, CAWCD may need to construct its own natural gas facility to obtain a baseload resource for summer months.

CAWCD may be able to use renewable resources (most likely solar) to supply a minor portion of its energy portfolio, but such resources cannot meet CAP's baseload need. Independent of the generation sources CAWCD chooses to replace NGS, it likely would be necessary to construct new transmission lines to deliver that energy to CAP pumps. There is little or no available transmission capacity that could convey energy to CAP pumps from the Palo Verde hub, which is the most likely delivery location for purchased power in Arizona. The amount, intensity, and duration of ground disturbance and construction-related noise and traffic from construction of a renewable energy facility would be dependent upon the type of facility being constructed.

ES1.5 Primary Technical Issues

The development of this EIS was shaped by several key technical issues that were defined during public scoping. The following is a summary of the key issues, and the technical studies that were performed to address these issues, where applicable. Available project-related materials are available for viewing or download at http://NGSKMC-EIS.net.

- Air Quality. Issues include local- and regional-scale air quality, including regional haze, ozone, and criteria air pollutants that would require modifications to NGS operations to comply with the USEPA Regional Haze Rule. Air quality modelling was conducted that characterized criteria and hazardous air pollutant concentrations; NGS stack plume visibility within 50 kilometers (km) of NGS; estimated NGS contributions to regional haze, ozone concentrations, and acid deposition in Class 1 air quality areas; and characterized criteria pollutant concentrations from operations at the proposed KMC.
- Climate Change. Issues include coal combustion contributions to regional and global greenhouse gas concentrations. Project (i.e., from NGS, proposed KMC, ancillary sources)

greenhouse gas emissions were estimated for the proposed operating period. Social costs of carbon were estimated from greenhouse gas emissions in accordance with federal agency methods.

- Water Resources on Black Mesa. Issues include past and continued mining-related withdrawals of N-Aquifer groundwater in relation to spring flows and groundwater contributions to surface water flows in major drainages. Groundwater modeling of the N-Aquifer was conducted to account for the aquifer drawdown and surface flow impacts of past, present, and future pumping from mining wells as well as withdrawals from community water supply wells.
- Ecological Risks from Trace Metal Deposition. Issues include ecosystem health effects of certain trace metals (mercury, arsenic, selenium) emitted from NGS stacks. The primary impact focus was on aquatic ecosystems in the Colorado River system, particularly threatened and endangered fish listed by the U.S. Fish and Wildlife Service. Soil, water, and sediment sampling were conducted in the vicinity of NGS and the proposed KMC to establish a current baseline. The results of this sampling were used as inputs to ecological risk assessments that were conducted in accordance with USEPA protocols. The endpoints of these assessments were predicted metal concentrations in plant, animal, and fish tissue, as well as potential toxicity.
- Public Health Risk from Trace Metal Deposition, Exposure to Fugitive Dust. Issues include human health impacts from accumulation of trace metals through the food chain and direct exposure from dust inhalation. The primary focus was on communities surrounding NGS (i.e., Page and LeChee) and residents living in the vicinity of the proposed KMC. The baseline soils, water, and air quality sampling data were used to conduct public health risk assessments for both NGS and the proposed KMC in accordance with USEPA protocols. The endpoints of these assessments were cancer and non-cancer risks. Other factors that contribute to community health, such as the availability of health care, also were evaluated.
- Cultural Resources on Black Mesa. Issues include discovery and treatment of cultural resources, including burials that would be removed prior to disturbance or avoided during surface coal mining and other project activities, and broader concerns about effects on special places of religious or cultural significance (Traditional Cultural Properties) from continued surface coal mining. Past cultural resource surveys on Black Mesa and along the transmission system ROWs were compiled into reports, and additional ground surveys were conducted in 2015 and 2016 within the proposed KMC coal resource areas and within the WTS corridor. Separate programmatic agreements, which provide guidance on the treatment of newly discovered cultural resources, were developed for NGS and the proposed KMC project components. These programmatic agreements were reviewed for approval by affected federal agencies, tribes, and states. Ethnographic studies conducted for the Navajo Nation, Hopi Tribe, and Pueblo of Zuni involve interviews with tribal elders, and traditional medicine practitioners to identify Traditional Cultural Properties and provide a perspective on the world views of tribal communities.
- Socioeconomic Impacts of NGS and Proposed KMC Operational Changes. Issues include potential reduced future employment at NGS and the proposed KMC and the economic and social consequences to worker families, communities, and tribal governments and increased pumping costs for CAP water as the result of operational changes at NGS. Assumptions regarding future employment and payments to tribes were made based on changes in volumes of coal burned at NGS and mined at the proposed KMC, which were then extrapolated in terms of changes in payrolls, government revenues, and public services in affected communities.

ES1.6 Affected Environment and Environmental Consequences

ES1.6.1 Affected Environment

The following paragraphs provide a brief summary of the study areas and the resource conditions that are described in the Affected Environment sections of the EIS. Where applicable, information from the ecological and human health risk assessments has been included to characterize baseline conditions in 2019.

Air Quality. Air quality was addressed at two geographic scales. The smaller study areas included a radius of 50 km around the NGS and the proposed KMC to document the measured concentrations of criteria and hazardous air pollutants that occur near these sources. The larger study area extended 300 km from NGS to address the airborne pollutant concentrations that contribute to visibility impairment, regional haze, and acid deposition. Study area pollutant concentrations are in compliance with national standards except for ozone in urban areas.

Climate and Climate Change. Greenhouse gas emissions from NGS and other project activities were addressed within the same study areas as air quality. Trends in greenhouse gas emissions at national and global scales show a long-term increase in global carbon dioxide concentrations, the primary indicator of global warming. Regional trends in natural resource responses to climatic factors include long-term reductions in annual streamflows within the Colorado River watershed, plant and animal distribution changes over time resulting from seasonal temperature changes, and observations by tribal communities that the availability of water for drinking, stock watering, and agriculture has become more variable.

Geology and Landforms. No unique geologic features or landforms underlying or near project components were identified. Earthquake and fault movement risks are very low based on the historical record.

Mineral Resources. Bituminous coal is the primary commercial mineral resource, and no interference with existing mining operations is occurring from other surface activities.

Paleontological Resources. The surficial geologic formations underlying the project components are considered to be of low scientific value.

Soil Resources. Soils underlying project components are characteristic of desert and semi-arid regions and generally are shallow with limited soil horizon development and organic matter. Soils are salvaged and stockpiled or replaced directly over final graded overburden at the proposed KMC to provide a suitable 4-foot thick revegetation medium. Trace metal concentrations in soils within 20 km of NGS generally are similar to regional background concentrations and do not exceed USEPA screening levels used to identify ecological and public health risks.

Water Resources. The water supply for NGS is Lake Powell, a large Colorado River reservoir that provides all water necessary for NGS operations at a quality suitable for industrial uses. The primary groundwater study area is the extent of the N-Aquifer, a regional aquifer that underlies Black Mesa. The N-Aquifer provides dust control and potable water for the proposed KMC as well as potable water for residents near the proposed KMC, including Navajo and Hopi communities. A variety of springs discharge from the N-Aquifer where the water-bearing zone contacts the land surface at distances of 5 to 10 miles from the proposed KMC. Flows in large washes that drain the upper elevations of Black Mesa are intermittent to ephemeral and are subject to periodic high flows from storm events. Surface water quality in Black Mesa wash channels is variable and generally suitable for livestock use.

Vegetation Resources. Vegetation communities within the study area are typical of desert and semi-arid regions, dominated by desert shrublands, sagebrush shrublands, and pinyon pine- juniper woodlands at higher elevations. Soil concentrations of trace metals within 20 km of NGS and at greater distances are not elevated and do not cause toxicity to native vegetation, based on the ecological risk assessments. Similarly, no toxicity risks to vegetation were identified from the proposed KMC under baseline conditions.

Special Status Vegetation Resources. No special status plants are known to occur within the existing and proposed activity areas for NGS and the proposed KMC. Seven special status plants (U.S. Fish and Wildlife Species and Navajo listed species) are known or potentially occur within 20 km of the NGS, no special status plants occur or potentially occur within the proposed KMC, and three special status plants occur or potentially occur in the N-Aquifer study area. Thirty-two species of special status plants are known or potentially occur within the WTS and STS ROWs. Baseline soil concentrations of trace metals within 20 km of NGS and at greater distances are not elevated and do not cause toxicity to special status plant species, based on the ecological risk assessments. Similarly, no toxicity risks to vegetation were identified from the proposed KMC under baseline conditions.

Terrestrial Wildlife Resources. Terrestrial wildlife habitats include the shrublands and woodlands described for vegetation. Riparian and open water habitats (except for Lake Powell) occupy very little of the study area and primarily are located with perennial drainages crossed by the WTS and STS (e.g., Agua Fria River, Virgin River) and intermittent drainages on Black Mesa. Primary terrestrial animal groups include big game, medium-sized and small mammals, and reptiles. Study areas where wildlife ecological risk assessments were conducted included the vicinity of NGS (Near-field); vicinity of proposed KMC; Colorado River upstream and downstream of Lake Powell (Gap Regions); and the San Juan River drainage from Lake Powell upstream to northwestern New Mexico. Based on ecological risk assessments of primary exposure pathways (i.e., air, soil, vegetation, and water), negligible trace metal impacts are present for all wildlife groups within all study areas under baseline conditions.

Terrestrial Wildlife Special Status Species. Based on habitat requirements, known and potential occurrence, and potential interaction with project components, the following federal species were selected for detailed assessment in the EIS: California condor, Mexican spotted owl, southwestern willow flycatcher, western yellow-billed cuckoo, Mojave Desert tortoise, Sonoran Desert tortoise, narrow-headed gartersnake, and northern Mexican gartersnake. Ten additional federal and tribal special status species occur or potentially occur within the NGS study area, six species occur or potentially occur within the proposed KMC and N-Aquifer study areas, and 50 species occur or potentially occur within the WTS and STS study areas. Negligible ecological risks from trace metals from assessment of primary exposure pathways (i.e., air, soil, vegetation, and water) are present for all special status wildlife groups within all study areas under baseline conditions (see Terrestrial Wildlife Resources above).

Aquatic Biological Resources. Primary aquatic habitats within the overall study area include Lake Powell, the Colorado and San Juan River upstream of Lake Powell, and the Colorado River downstream of Lake Powell to Lake Mead. Fish in these river and reservoir habitats mostly are non-native species. Striped bass in Lake Powell and rainbow trout in the Colorado River below Glen Canyon are important recreational species. Based on measured water quality and fish tissue concentrations, potential risks to fish populations in the Colorado River below Lake Powell are present from exposure to mercury and selenium and to fish populations in the San Juan River from exposure to selenium. Negligible risks to aquatic communities in ponds and drainages on the proposed KMC are present under baseline conditions.

Special Status Aquatic Species. Based on habitat requirements, known and potential occurrence, and potential interaction with project components, the following federal aquatic species were selected for detailed assessment in the EIS: bonytail, Colorado pikeminnow, humpback chub, razorback sucker, Kanab ambersnail, desert pupfish, gila chub, gila topminnow, loach minnow, roundtail chub, spikedace, Virgin River chub, and woundfin. An additional 11 species of fish and amphibians are known or potentially occur within the WTS and STS transmission line study areas. Based on measured water quality and fish tissue concentrations, potential risks are present under baseline conditions to Colorado pikeminnow populations in the San Juan River from exposure to mercury, to razorback sucker populations in the Colorado River below Lake Powell from exposure to mercury, and to razorback sucker populations in the San Juan River from exposure to mercury and selenium.

Land Use. NGS and portions of the proposed KMC, WTS, and STS are located on Navajo Nation lands. Other ownerships include the National Park Service (for the water pipeline from Lake Powell to NGS), Hopi Tribe for southern portions of the proposed KMC, and BLM and U.S. Forest Service for portions of the WTS and STS. A variety of BLM special designation areas are crossed by the transmission lines. The primary land use is for livestock grazing while wildlife habitat and cultural plants are important at the proposed KMC. The entire region is sparsely populated. The communities of Page and LeChee are located within 5 miles of NGS; small (approximately 150 people) dispersed residential clusters are located within or near the proposed KMC. Lands disturbed by mining activity are progressively revegetated. Revegetated lands at the proposed KMC are returned to the Navajo Nation or Hopi Tribe, subject to release of a performance bond administered by the OSMRE and BIA approvals.

Public Safety. The NGS plant site is not accessible to the public. The primary NGS ground-level activities that may affect the public and public resources include coal delivery by railroad, truck delivery of products and industrial chemicals, and coal ash disposal, which includes sales of fly ash. Fly ash is removed from the plant site by truck. Warning signs are provided for at-grade road crossings of the Black Mesa and Lake Powell (BM&LP) Railroad. The active mine area at the proposed KMC is not accessible to the public, but a public road (Navajo Route 41) traverses 2 to 3 miles west of active mining areas, and individual residences are scattered throughout the proposed KMC area. Residents are relocated away from active mining pits to minimize exposure from periodic overburden blasting events and noise from mining activities. No residential structures are located within the WTS and STS ROWs, limiting long-term human exposure to potential electromagnetic radiation from transmission line conductors.

Public Health and Human Health Risk. The study areas for the human health risk assessments included the vicinity of NGS (out to 20 km from the source) and the area within the proposed KMC. The focus of the risk assessments was human exposure to trace metals via various pathways (i.e., air, soil, water, and food consumption). Based on human health risk assessments, baseline conditions for cancer risks for populations near NGS are within the USEPA-acceptable range, except for child recreational users who may be exposed to methyl mercury from consuming fish caught from Lake Powell. Blood lead concentrations are well below USEPA target blood levels under baseline conditions. Cancer and non-cancer risks for residents within the proposed KMC are within the USEPA acceptable range, and the proposed KMC resident lead concentrations are well below USEPA target blood levels, under baseline conditions.

The human population and public health services considered for the community health assessment included the inhabitants of the Navajo Nation and Hopi Tribe within the study areas defined for human health risk. The focus of this assessment was on contaminant exposure and stress factors, economic factors, and institutional factors contributing to community health. The primary contaminant factors (fugitive dust) are addressed in the human health risk assessment. The proposed KMC residential exposure to noise and blasting, potential for residential relocation as mining advances, changes in access to livestock grazing areas, and concerns about cultural resources removal potentially are important stress factors. Beneficial economic factors include employment, increased income, and access to health care; the inverse of these factors include unemployment without other employment options and inadequate income to purchase services, including health care. Health surveys indicate that the Navajo County population is among the least healthy in Arizona. Key negative health indicators include high incident rates for obesity, smoking, alcohol use, diabetes, cancer, cardiovascular disease, respiratory disease, and accidents. Outside air quality conditions at ground level are within air quality standards (see Air Quality).

Cultural Resources. Study areas for cultural resources include all the surface area already committed to project components, plus the proposed KMC coal resource areas that would be mined between 2020 and 2044. Additional ground surveys for cultural resources have been, or would be completed in areas where there are data gaps (WTS) and areas proposed for coal mining during the 2020-2044 period. Ethnographic/Traditional Cultural Properties studies are being completed for the Navajo Nation, Hopi Tribe, and Pueblo of Zuni. This region has been occupied by Native Americans over a period of nearly

10,000 years, and many examples of hunter/gatherer sites, as well as settlements supported by agriculture, have been discovered and described. Four archeological sites have been identified within the NGS plant site, 60 sites within the BM&LP Railroad ROW, and approximately 2,760 sites within the proposed KMC, which includes the former Black Mesa Mine and existing Kayenta Mine. Seventy-two places of religious and cultural significance to local individuals and families within the proposed KMC have been identified to date. A range of 200 to 224 archaeological sites currently are known from areas proposed to be mined from 2020 to 2044, numbers that may increase as a result of additional surveys. Twenty-four Traditional Cultural Properties, including places with known or expected burials, have been identified in areas proposed for new mining. One hundred twenty-nine (129) archaeological sites have been identified within the WTS corridor; additional sites are anticipated to be identified based on the new survey. Three hundred twenty archaeological sites are associated with the STS, which has been completely surveyed. Nine archaeological sites have been identified from surveys on 15 communications sites; 5 communications sites are considered possible Traditional Cultural Properties because they are located on regional highpoints.

Socioeconomics. The local socioeconomic study area encompasses the Navajo Nation chapters that surround NGS and the proposed KMC and the entire Hopi Reservation. A regional study area includes the communities and infrastructure within Coconino, Navajo, and Apache counties in Arizona, as well as the Navajo Nation in western New Mexico. Also included in a regional study area are lands of ten southern Arizona tribes with CAP water allocations.

Navajo Nation tribal enrollment is more than 300,000 people; Hopi tribal enrollment is approximately 14,000 people. Tribal member unemployment is high, and income is low compared to Arizona as a whole. Primary employment sources are the public sector, agriculture, mining, utilities, and tourism. In 2014, NGS employed 495 workers, of which 86 percent were Native American. The Kayenta Mine employed 440 workers, of which 96 percent were Native American. NGS Participant payments to the Navajo Nation and property taxes exceed $50 million annually. Royalties, taxes, and other fees paid by PWCC to tribal and local governments total more than $57 million annually. PWCC provides potable water, road maintenance, emergency response capability, heating coal, and infrastructure services and maintenance as benefits to the nearby communities.

The 10 tribes with CAP water allocations occupy reservations with a land area in excess of 6.7 million acres, and receive annual allocations of almost 576,000 acre-feet of Colorado River water per year. Household incomes of tribal members generally are below state and national averages, and poverty rates generally are above county averages. The CAWCD purchases 90 percent of its electrical energy from NGS. In 2014, net water delivery charges were $188 million. The 2014 pumping energy costs equate to $67 per acre foot.

Environmental Justice. The study areas for environmental justice are the same as those described for socioeconomics. The populations living in these study areas meet the environmental justice guidelines for minority and low-income residents.

Indian Trust Assets. Indian trust assets are legal interests in property held in trust by the U.S. for Indian tribes or individuals. Trust assets may include lands, minerals, hunting and fishing rights, and water rights. Indian trust assets addressed in this EIS include:

- NGS – water and land trust assets;
- Proposed KMC – water, land, mineral, and hunting trust assets;
- Transmission lines and communication sites – land trust assets; and
- CAP – water trust assets.

ES1.6.2 Environmental Consequences

Table ES-2 provides a summary of the NGS and KMC land and water requirements for the alternatives, power generation assumptions, key air pollutant emissions, and employment, labor income, and lease and other payments. This table provides an overview of impact sources that contribute to the impact summary presented in **Table ES-3**.

Table ES-3 displays a summary of the impacts of all the alternatives on the various resources discussed in the EIS. The No Action Alternative provides a baseline against which the impacts of the action alternatives are compared. Due to the nature and extent of the assumptions made when conducting the technical studies used to compare the impacts resulting from each alternative, the analyses provide more value as a comparison across alternatives, rather than as a prediction of actual changes that would occur for a particular resource area.

ES1.7 References

Arizona Department of Health Services. 2012 – Arizona Behavioral Risk Factor Surveillance System Survey. Arizona Department of Health Services. Internet website: http://www.azdhs.gov/phs/phstats/brfs/index.htm. Accessed July 22, 2016.

Central Arizona Water Conservation District. 2013. Central Arizona Project, 2014-2015 Biennial Budget. Internet website: http://www.cap-az.com . Accessed October 2014.

National Renewable Energy Laboratory. 2015. Mead Wholesale Energy Market and Natural Gas Prices – Technical Memorandum from T. Tian, D. Hurlbut, and J. Cook (NREL) to R. Callejo, D. Hurlbut, and J. Cook, Bureau of Reclamation. October 1, 2015.

Navajo Nation, et al. 2013. Lease Amendment No. 1. Amendment No. 1 to Indenture of Lease, Navajo Units 1, 2 and 3 between the Navajo Nation and Arizona Public Service Company, Department of Water and Power of City of Los Angeles, Nevada Power Company dba NV Energy, Salt River Project Agricultural Improvement and Power District, Tucson Electric Power Company.

Navajo Nation, et al. 1969. Navajo Project Indenture of Lease of 1969. Indenture of Lease, Navajo Units 1, 2 and 3 between the Navajo Tribe of Indians and Arizona Public Service Company, Department of Water and Power of City of Los Angeles, Nevada Power Company, Salt River Project Agricultural Improvement and Power District, and Tucson Gas and Electric Company. Internet website: http://ngskmc-eis.net/wp-content/uploads/2014/07/Navajo-Project-Indenture-of-Lease-1969.pdf. Accessed May 24, 2016.

Table ES-2 Navajo Generating Station – Kayenta Mine Complex Project Quantitative Impact Summary

Resource Requirement / Operational Factor	Proposed Action		Natural Gas PFR Alternative (100-MW and 250-MW reduction)		Renewable PFR Alternative (100-MW and 250-MW reduction)		Tribal PFR Alternative (100-MW and 250-MW reduction)	
	3–Unit	2–Unit	3–Unit	2–Unit	3–Unit	2–Unit	3–Unit	2–Unit
Navajo Generating Station / BM&LP Railroad / Western and Southern Transmission Systems								
Land Requirements (Maximum)								
NGS Plant Site (acres)	2,104	2,064	2,104	2,064	2,104	2,064	2,104 +3,000 for new solar site	2,064 +1,200 for new solar site
BM&LP Railroad ROW (acres)	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620
WTS, STS, Substations, Communication Sites; ROW and roads (acres)	27,315	27,315	27,315	27,315	27,315	27,315	27,315 + new tie-line ROW	27,315 + new tie-line ROW
Natural Resource Requirements								
Water from Lake Powell for NGS (acre-feet/year)	29,000	19,340	-100 MW: 27,840 -250 MW: 25,230	-100 MW: 17,986 -250 MW: 16,052	-100 MW: 28,103 -250 MW: 27,260	-100 MW: 18,566 -250 MW: 17,406	-100 MW: 28,420 -250 MW: 27,550	-100 MW: 18,670 -250 MW: 17,986
Coal delivered from Kayenta Mine (million tpy)	8.1	5.5	-100 MW: 7.7 -250 MW: 7.1	-100 MW: 5.1 -250 MW: 4.5	-100 MW: 7.9 -250 MW: 7.5	-100 MW: 5.3 -250 MW: 4.9	-100 MW: 7.9 -250 MW: 7.7	-100 MW: 5.3 -250 MW: 5.1
Power and Energy Generation								
Design power capacity; NGS at 88% capacity (MW)	1,980	1,320	-100 MW: 1,880 -250 MW: 1,730	-100 MW: 1,220 -250 MW: 1,070	-100 MW: 1,922 -250 MW: 1,834	-100 MW: 1,268 -250 MW: 1,174	-100 MW: 1,939 -250 MW: 1,877	-100 MW: 1,279 -250 MW: 1,217
Federal energy from NGS (terawatt hours/year)	4.17	4.12	-100 MW: 3.29 -250 MW: 1.98	-100 MW: 3.24 -250 MW: 1.93	-100 MW: 3.66 -250 MW: 2.89	-100 MW: 3.61 -250 MW: 2.84	-100 MW: 3.83 -250 MW: 3.33	-100 MW: 3.78 -250 MW: 3.28
Federal energy from NGS supplied to CAP (terawatt hours/year)	2.70	2.70	-100 MW: 1.82 -250 MW: 0.51	-100 MW: 1.82 -250 MW: 0.51	-100 MW: 2.19 -250 MW: 1.42	-100 MW: 2.19 -250 MW: 1.42	-100 MW: 2.36 -250 MW: 1.86	-100 MW: 2.36 -250 MW: 1.86
Alternative energy source to CAP (terawatt hours/year)	--	–	-100 MW: 0.88 -250 MW: 2.19	-100 MW: 0.88 -250 MW: 2.19	-100 MW: 0.51 -250 MW: 1.28	-100 MW: 0.51 -250 MW: 1.28	-100 MW: 0.33 -250 MW: 0.83	-100 MW: 0.33 -250 MW: 0.83
NGS energy available as surplus (terawatt hours/year)	1.47	1.42	1.47	1.42	1.47	1.42	1.47	1.42

Table ES-2 Navajo Generating Station – Kayenta Mine Complex Project Quantitative Impact Summary

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	3–Unit	2–Unit	3–Unit	2–Unit	3–Unit	2–Unit	3–Unit	2–Unit
Annual energy charges to CAP; maximum cost/year for 2030 to 2044 operations (million dollars)	144.8	152.3	-100 MW: 153.4 -250 MW: 180.1	-100 MW: 168.5 -250 MW: 179.6	-100 MW: 155.0 -250 MW: 167.2	-100 MW: 161.2 -250 MW: 172.0	-100 MW: 151.5 -250 MW: 160.6	-100 MW: 158.5 -250 MW: 165.9
Selected Emissions								
Annual nitrogen dioxide (NO_X) – pre SCR installation (tpy)	20,409	13,606	-100 MW: 19,461 -250 MW: 18,039	-100 MW: 12,658 -250 MW: 11,236	-100 MW: 19,811 -250 MW: 18,914	-100 MW: 13,008 -250 MW: 12,111	-100 MW: 20,019 -250 MW: 19,436	-100 MW: 13,216 -250 MW: 12,633
Annual nitrogen dioxide (NO_X) – post SCR installation (tpy)	6,803	4,535	-100 MW: 6,542 -250 MW: 6,151	-100 MW: 4,274 -250 MW: 3,883	-100 MW: 6,606 -250 MW: 6,310	-100 MW: 4,338 -250 MW: 4,042	-100 MW: 6,674 -250 MW: 6,482	-100 MW: 4,406 -250 MW: 4,214
Greenhouse gases; carbon dioxide equivalent (million tpy)	18.38	12.30	-100 MW: 17.86 -250 MW: 17.07	-100 MW: 11.77 -250 MW: 10.98	-100 MW: 17.86 -250 MW: 17.08	-100 MW: 11.78 -250 MW: 10.99	-100 MW: 18.05 -250 MW: 17.53	-100 MW: 11.96 -250 MW: 11.45
Employment, Income, and Payments								
Regional jobs (direct, indirect, and induced) – typical year (full–time equivalents)	2,164	1,616	-100 MW: 2,077 -250 MW: 1,999	-100 MW: 1,535 -250 MW: 1,453	-100 MW: 2,096 -250 MW: 2,054	-100 MW: 1,559 -250 MW: 1,509	-100 MW: 2,125 -250 MW: 2,113 + 533 or 636 construction jobs, respectively, for 1.5 or 2.5 to 3 yr.	-100 MW: 1,586 -250 MW: 1,568 + 533 or 636 construction jobs, respectively, for 1.5 or 2.5 to 3 yr.
Annual labor income (direct, indirect, induced) – (million dollars)	149.8	110.8	-100 MW: 142.6 -250 MW: 133.5	-100 MW: 105.4 -250 MW: 96.5	-100 MW: 144.3 -250 MW: 139.6	-100 MW: 107.9 -250 MW: 102.6	-100 MW: 146.0 -250 MW: 143.8 + 1.0 or 1.4, respectively, for new photovoltaic	-100 MW: 96.1 -250 MW: 93.8 + 1.0 or 1.4, respectively, for new photovoltaic
Total NGS lease and other payments to the Navajo Nation; 2020 to 2044 (billion dollars)	1.075	0.79	1.075	0.79	1.075	0.79	1.075 + 0.035 to 0.087 for new photovoltaic	0.79 + 0.035 to 0.087 for new photovoltaic

Table ES-2 Navajo Generating Station – Kayenta Mine Complex Project Quantitative Impact Summary

Resource Requirement / Operational Factor	Proposed Action		Natural Gas PFR Alternative (100-MW and 250-MW reduction)		Renewable PFR Alternative (100-MW and 250-MW reduction)		Tribal PFR Alternative (100-MW and 250-MW reduction)	
	3–Unit	**2–Unit**	**3–Unit**	**2–Unit**	**3–Unit**	**2–Unit**	**3–Unit**	**2–Unit**
Proposed Kayenta Mine Complex (KMC)								
Land Requirements (Maximum)								
Coal resource areas (acres)	31,475	30,986	31,475	30,986	31,475	30,986	31,475	30,986
Resource Requirements								
Coal to be mined; 2020 to 2044 (million tpy)	8.1	5.5	-100MW: 7.7 -250 MW: 7.1	-100 MW: 5.1 -250 MW: 4.5	-100 MW: 7.9 -250 MW: 7.5	-100 MW: 5.3 -250 MW: 4.9	-100 MW: 7.9 -250 MW: 7.7	-100 MW: 5.3 -250 MW: 5.1
Surface disturbance from mining; 2020 to 2044 (acres)	5,230	4,741	-100MW: 4,968 -250MW: 4,602	-100 MW: 4,409 -250 MW: 3,888	-100 MW: 5,072 -250 MW: 4,863	-100 MW: 4,551 -250 MW: 4,267	-100 MW: 5,724 -250 MW: 4,968	-100 MW: 4,599 -250 MW: 4,409
Groundwater use; 202 to 2044 (acre-feet/year)	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Selected Emissions								
Greenhouse gases; carbon dioxide equivalent (tpy)	71,000	54,000	-100 MW: 68,000 -250 MW: 64,000	-100 MW: 51,000 -250 MW: 47,000	-100 MW: 69,000 -250 MW: 67,000	-100 MW: 52,000 -250 MW: 50,000	-100 MW: 70,000 -250 MW: 68,000	-100 MW: 53,000 -250 MW: 51,000
Employment, Income, and Payments								
Employment (full-time equivalents)	1,648	1,129	-100 MW: 1,573 -250 MW: 1,453	-100 MW: 1,052 -250 MW: 939	-100 MW: 1,603 -250 MW: 1,534	-100 MW: 1,084 -250 MW: 1,017	-100 MW: 1,618 -250 MW: 1,566	-100 MW: 1,095 -250 MW: 1,052
Annual labor income; direct, indirect, induced (million dollars)	110.7	75.8	-100 MW: 105.6 -250 MW: 97.6	-100 MW: 70.4 -250 MW: 62.7	-100 MW: 107.8 -250 MW: 103.0	-100 MW: 72.5 -250 MW: 68.1	-100 MW: 108.7 -250 MW: 105.2	-100 MW: 73.3 -250 MW: 70.4
Total PWCC lease, royalty, bonus, and water payments: 2020 to 2044 (billion dollars)	1.19	0.82	-100 MW: 1.14 -250 MW: 1.05	-100 MW: 0.76 -250 MW: 0.68	-100 MW: 1.16 -250 MW: 1.11	-100 MW: 0.79 -250 MW: 0.74	-100 MW: 1.17 -250 MW: 1.14	-100 MW: 0.80 -250 MW: 0.76

Table ES-3 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.1 Air Quality	The project would be in compliance with national ambient air quality standards, and maximum impacts from both facilities primarily would occur near the sources and decrease with distance. Overall project air quality impacts from 2020 to 2044 (including regional haze and ozone) would be minor to moderate near NGS and the proposed KMC. Source emissions would be reduced by various controls, ranging from stack scrubbers at NGS to watering of haul roads for dust control at the proposed KMC. Deposition of selenium from the proposed KMC would be minor; all other deposition would be negligible. Short-term moderate increases in fugitive dust and equipment emissions would occur during decommissioning over a 1-year period at NGS and a minimum 10-year period at the proposed KMC starting in 2044. In the event some or all of the transmission systems and communication site ROWs (estimated at 4,826 acres) are not renewed/decommissioned,	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Project compliance with air quality standards would be the same as the Proposed Action. Overall project air quality impacts from 2020 to 2044 (including regional haze and ozone) would be minor to moderate near NGS and the proposed KMC. Stack emissions from NGS would be 5 to 19 percent less, and proposed KMC surface disturbance would be 5 to18 percent less than the Proposed Action. Short-term minor increases in fugitive dust and equipment emissions would occur as described for the Proposed Action decommissioning. WTS and STS operations would continue as described for the Proposed Action. Cumulative impacts would be slightly less than for the Proposed Action, and dominated by non-project activities.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Project compliance with air quality standards would be the same as the Proposed Action. Overall project air quality impacts from 2020 to 2044 (including regional haze and ozone) would be minor to moderate near NGS and the proposed KMC. Stack emissions from NGS would be 3 to 11 percent less, and proposed KMC surface disturbance would be 3 to10 percent less than the Proposed Action. Short-term minor increases in fugitive dust and equipment emissions would occur as described for the Proposed Action decommissioning. WTS and STS operations would continue as described for the Proposed Action. Cumulative impacts would be slightly less than for the Proposed Action and dominated by non-project activities.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Air quality impacts would be analyzed in a subsequent NEPA action. Project compliance with air quality standards would be the same as the Proposed Action. Overall project air quality impacts from 2020 to 2044 (including regional haze and ozone) would be minor to moderate near NGS and the proposed KMC. Stack emissions from NGS would be 2 to 8 percent less, and proposed KMC surface disturbance would be 2 to 7 percent less than the Proposed Action. Short-term minor increases in fugitive dust and equipment emissions would occur as described for the Proposed Action decommissioning. WTS and STS operations would be as described for the Proposed Action.	NGS stack emissions and Kayenta Mine mining activity emissions would cease in 2019. Air pollutant ground level concentrations would return to background levels. Short-term moderate increases in fugitive dust and equipment emissions would occur during decommissioning operations at both NGS (2018-2019) and the Kayenta Mine (over minimum 10-year period starting in 2019). The NGS transmission system is an established part of the western U.S. transmission grid and supports reliability and delivery of power throughout the region, beyond the power from NGS. Under the No Action Alternative, it is likely that that one, several, or all of the land owners/managers of the transmission line ROWs and communication site leases would renew all or part of the facilities to maintain expected power grid performance. In the event some or all of the transmission systems and communication site ROWs (estimated at 4,826 acres total) are not renewed, a lengthy study and permitting process, and

Table ES-3 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.1 Air Quality (continued)	a lengthy study and permitting process, and construction of replacement facilities, would precede any decommissioning due to the essential and integral nature of these facilities with the western electric grid. Cumulative impacts regionally (within 300 km of NGS) would be major for ozone, and minor to major for acid deposition due to the additive effects of NGS and other sources. Maximum cumulative criteria pollutant impacts would be minor. Cumulative regional haze would be moderate.			Cumulative impacts would be slightly less than for the Proposed Action and dominated by non-project activities.	construction of any replacement facilities, would precede any decommissioning due to the essential and integral nature of these facilities with the western electric grid.
3.2 Climate and Climate Change	Future Project greenhouse gas emissions are estimated to range between 18.4 (3-unit) and 12.3 (2-unit) million metric tons per year over the period 2020-2044. Over this time frame, it is estimated that global greenhouse gas emissions would increase 52 percent because of increased energy demands, a major cumulative impact. Because NGS-KMC Project's greenhouse emissions would be constant, they would represent a declining share of the overall global increase.	Future Project greenhouse gas emissions are estimated to range between 17.9 and 17.1 (3-unit) and 11.8 and 11.0 (2-unit) million metric tons per year over the period 2020-2044. These emissions represent a 12 to 30 percent greenhouse gas reduction relative to the Proposed Action because natural gas-generated energy purchased from the market would be substituted for coal combustion at NGS.	Future Project greenhouse gas emissions are estimated to range between 17.9 and 17.1 (3-unit) and 11.8 and 11.0 (2-unit) million metric tons per year over the period 2020-2044. These emissions represent a 12 to 30 percent greenhouse gas reduction relative to the Proposed Action because renewable source-generated energy purchased from the market would be substituted for coal combustion at NGS.	Future Project greenhouse gas emissions are estimated to range between 18.1 and 17.6 (3-unit) and 12.0 and 11.5 (2-unit) million metric tons per year over the period 2020-2044. These emissions represent an 8 to 19 percent greenhouse gas reduction relative to the Proposed Action because renewable energy, generated from a photovoltaic solar facility on tribal land, would be substituted for coal combustion at NGS.	After NGS and the Kayenta Mine cease operations in 2019 under the 1969 lease and other existing arrangements, it is assumed that federal share replacement power for the CAP system would be provided by a natural gas combined cycle source. On this basis, 8.6 metric tons of greenhouse gases would be emitted, or 53 percent less than the Proposed Action 3-unit operation, and 30 percent less than the Proposed Action 2-unit operation.

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Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.3 Geology	NGS and proposed KMC components and operations would not impact unique geologic features and would be exposed to minor risk from damage during an earthquake event from 2020 through 2044. Mining at proposed KMC and coal combustion disposal would result in minor impact to land forms. The WTS and STS would continue operations as described under the Air Quality Proposed Action and no impacts to unique geologic resources are anticipated. The WTS would be at minor risk of damage from earthquakes because of its proximity to active faults and higher potential ground motion during an earthquake.	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Impacts to unique geologic resources, land forms, and as a result of geologic hazards would be the same as the Proposed Action, except that 5 to 18 percent less mining surface disturbance would occur at the proposed KMC, resulting in less impact to land forms.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Impacts to unique geologic resources, land forms, and as a result of geologic hazards would be the same as the Proposed Action, except that 3 to 10 percent less mining surface disturbance would occur at the proposed KMC, resulting in less impact to land forms.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Geology resource impacts would be analyzed in a subsequent NEPA action. Impacts to unique geologic resources, land forms, and as a result of geologic hazards would be the same as the Proposed Action, except that 2 to 7 percent less mining surface disturbance would occur at the proposed KMC, resulting in less impact to land forms.	Demolition and mine closure after 2019 would have no impact to unique geologic resources and negligible impacts to land forms as a result of reclamation activities. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative. The WTS would be at minor risk of damage from earthquakes because of its proximity to active faults and higher potential ground motion during an earthquake.
3.4 Minerals	Negligible project impacts to mineral resource availability because of the absence of known commercially extractable minerals except for coal at the proposed KMC. Coal resources at the proposed KMC would be adequate to meet NGS power generation commitments. The WTS and STS would	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Mineral resource occurrence and availability impacts would be the same as the Proposed Action, except that 5 to 18 percent less mining surface disturbance would occur at the proposed KMC.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Mineral resource occurrence and availability impacts would be the same as the Proposed Action, except that 3 to 10 percent less mining surface disturbance would occur at the proposed KMC.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Mineral resource impacts would be analyzed in a subsequent NEPA action. Mineral resource occurrence and availability impacts would be the same as the	Negligible impacts on mineral resources from decommissioning at NGS, BM&LP Railroad, and the Kayenta Mine after 2019. Impacts as described in the Proposed Action would not occur because coal extraction from 5,230 to 4,741 acres at Kayenta Mine after 2019 would not occur. Impacts to the WTS and STS are

Table ES-3 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
	continue operations as described under the Air Quality Proposed Action.			Proposed Action, except that 2 to 7 percent less mining surface disturbance would occur at the proposed KMC.	the same as described for the Air Quality No Action Alternative.
3.5 Paleonto-logical	Negligible project surface disturbance impacts to fossil resources because of the generally low to moderate fossil importance rank of the bedrock formations, and the recommended unanticipated discovery protection measure at proposed KMC. The WTS and STS would continue operations as described under the Air Quality Proposed Action.	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Paleontological resource impacts would be the same as the Proposed Action, except that 5 to 18 percent less mining surface disturbance would occur at the proposed KMC.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Paleontological resource impacts would be the same as the Proposed Action, except that 3 to 10 percent less mining surface disturbance would occur at the proposed KMC.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Paleontological resource impacts would be analyzed in a subsequent NEPA action. Paleontological resource impacts would be the same as the Proposed Action, except that 2 to 7 percent less mining surface disturbance would occur at the proposed KMC.	Negligible impacts on paleontological resources from decommissioning NGS, BM&LP Railroad, and the Kayenta Mine after 2019. Impacts as described in the Proposed Action would not occur because coal extraction from 5,230 to 4,741 acres at Kayenta Mine after 2019 would not occur. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative.

Table ES-3 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.6 Soil	Moderate project soil surface disturbance impacts from 2020 to 2044 would range from 4,998 to 5,527 acres. Soils and suitable revegetation material would be salvaged and protected in accordance with federal regulatory programs and lease terms. Minor trace metal deposition impacts. Predicted trace metal deposition would not cause applicable EPA soil screening levels to be exceeded or contribute to unacceptable human or ecological risks. After 2044, 10,123 acres on NGS, the BM&LP Railroad, and the proposed KMC would require reapplication of soil or suitable revegetation materials and seeded. The WTS and STS would continue operations as described under the Air Quality Proposed Action. Proposed Action contributes 7 to 8 percent to estimated cumulative soil disturbance of 61,985 to 62,514 acres, a moderate cumulative impact.	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate project soil disturbance impacts from 2020 to 2044 would be 5 to 18 percent less than the Proposed Action because less coal would be mined. Minor trace metal deposition impacts would be 5 to 19 percent less than the Proposed Action. Decommissioning after 2044 also would be proportionally less. Cumulative impacts slightly less than Proposed Action.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate project soil disturbance impacts from 2020 to 2044 would be 3 to 10 percent less than the Proposed Action because less coal would be mined. Minor trace metal deposition would be 2 to 12 percent less than the Proposed Action. Decommissioning after 2044 also would be proportionally less. Cumulative impacts slightly less than Proposed Action.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Soil resource impacts would be analyzed in a subsequent NEPA action. Moderate project soil disturbance impacts from 2020 to 2044 would be 2 to 7 percent less than the Proposed Action because less coal would be mined. Minor trace metal deposition impacts would be 2 to 11 percent less than the Proposed Action. Decommissioning after 2044 also would be proportionally less. Cumulative impacts slightly less than Proposed Action.	Demolition and mine closure after 2019 would require topsoiling and seeding on 9,272 acres. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative. Soil protection, and erosion and sediment control programs, and transmission line and communication site operation and maintenance activities would be the same as those described for the Proposed Action. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative.

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Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.7 Water	Moderate to negligible project impacts from 2020 to 2056 to surface water and groundwater water quantity and quality. Moderate impacts include modifications in surface flows in major washes downstream from the proposed KMC caused by changes in location and capacity of storage ponds. Minor project impacts include mine pumping drawdown of N-Aquifer utilized by nearby community wells, increases in community well pumping costs; and changes in water levels in the Wepo aquifer that may affect community surface water uses, and water quality. The Project is projected to contribute minor reductions in future N-Aquifer drawdown, but cumulative drawdown from all sources is predicted to be major (see No Action). The WTS and STS would continue operations as described under the Air Quality Proposed Action.	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate and minor project impacts from 2020 to 2044 would be the same as the Proposed Action except that 5 to 18 percent less mining surface disturbance would occur at the proposed KMC, which may modify plans for stormwater retention. Proposed KMC groundwater pumping demands would remain the same. Cumulative impacts would be similar to the Proposed Action.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate and minor project impacts from 2020 to 2044 would be the same as the Proposed Action except that 3 to 10 percent less mining surface disturbance would occur at the proposed KMC, which may modify plans for stormwater retention. Proposed KMC groundwater pumping demands would remain the same. Cumulative impacts would be similar to the Proposed Action.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Water resource impacts would be analyzed in a subsequent NEPA action. Moderate and minor project impacts from 2020 to 2044 would be the same as the Proposed Action except that 2 to 7 percent less mining surface disturbance would occur at the proposed KMC, which may modify plans for stormwater retention. Proposed KMC groundwater pumping demands would remain the same. Cumulative impacts would be similar to the Proposed Action.	By ceasing Kayenta Mine operations in 2019, mine drawdown impacts on nearby community wells and pumping costs would be negligible. Major to moderate N-Aquifer water level impacts are predicted as the result of community pumping through 2057 when up to 150 feet of drawdown is predicted. Major baseflow declines in Chinle Creek, Laguna Creek, and Polacca Wash would largely result from projected community pumping. Simulated reductions in flow at both monitored and non-monitored springs also are predicted to result from increases in community pumping over time. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative.

Table ES-3 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.8 Vegetation	Moderate to negligible project impacts on vegetation. Moderate project vegetation removal impacts from 2020 to 2044 would range from 4,998 to 5,527 acres. Disturbed areas would be reseeded with approved mixtures, and monitored for release back to the Navajo Nation and Hopi Tribe. Re-establishment of grassland communities would require 5 years; shrublands and woodlands from 25 to 50 years. Minor project impacts from noxious weeds which could quickly expand across disturbed areas. Weed populations would be targets of ongoing control during reclamation. After 2044, 10,123 acres of project surface disturbance would require reapplication of soil followed by reseeding, and approved for release to the land owner. The WTS and STS would continue operations as described under the Air Quality Proposed Action. Project vegetation removal	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate project vegetation removal impacts from 2020 to 2044 would be 5 to 18 percent less than the Proposed Action because less coal would be mined; decommissioning requirements also would be proportionally less. Moderate cumulative vegetation removal impacts would be slightly less than the Proposed Action because of less surface disturbance on the proposed KMC.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate project vegetation removal impacts from 2020 to 2044 would be 3 to 10 percent less than the Proposed Action because less coal would be mined; decommissioning requirements after 2044 would be proportionally less. Moderate cumulative vegetation removal impacts would be slightly less than the Proposed Action because of less surface disturbance on the proposed KMC.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Vegetation resource impacts would be analyzed in a subsequent NEPA action. Moderate project vegetation removal impacts from 2020 to 2044 would be 2 to 7 percent less than the Proposed Action because less coal would be mined; decommissioning requirements after 2044 also would be proportionally less. Moderate cumulative vegetation removal impacts would be slightly less than the Proposed Action because of less surface disturbance on the proposed KMC.	Demolition and mine closure after 2019 would require seeding on 9,272 acres. Seeding requirements would be the same as those for the Proposed Action. Negligible impacts to native riparian communities in major washes near Kayenta Mine from community pumping because of predicted reductions in baseflows, Primary areas of concern are Chinle Creek, Laguna Creek, and Polacca Wash, where native riparian vegetation communities are not present, or are extremely small and isolated. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative.

Table ES-3 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.8 Vegetation (continued)	impacts from 2020-2044 would contribute 7 to 8 percent of up to 61,985 to 62,514 acres of moderate cumulative vegetation removal impacts.				
3.9 Special Status Vegetation Resources	Negligible project impacts on special status plants. Negligible potential surface disturbance impacts to special status plants from O&M activities in transmission line ROW; negligible loss of special status plants and populations from project new surface disturbance, and N-Aquifer drawdown. The WTS and STS would continue operations as described under the Air Quality Proposed Action. Minor cumulative risks for loss of special status plants from foreseeable utility construction activities adjacent to, or near the WTS ROW.	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Negligible project impacts on special status plants. Minor cumulative risks for loss of special status plants from foreseeable utility construction activities adjacent to, or near the WTS ROW.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Negligible project impacts on special status plants. Minor cumulative risks for loss of special status plants from foreseeable utility construction activities adjacent to, or near the WTS ROW.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Special status vegetation impacts would be analyzed in a subsequent NEPA action. Negligible project impacts on special status plants. Minor cumulative risks for loss of special status plants from foreseeable utility construction activities adjacent to, or near the WTS ROW.	Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative. O&M activities would occur along transmission line access roads, and periodic repairs may be required. Negligible risk of special status plant disturbance.
3.10 Terrestrial Wildlife	Moderate to negligible impacts to wildlife habitat and populations. Moderate impacts on wildlife habitat from vegetation removal; moderate impacts from direct losses of individuals from collisions, and electrocution; habitat avoidance impacts from human activities	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate habitat removal impacts from 2020 to 2044 would be 5 to 18 percent less than the Proposed Action	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate habitat removal impacts from 2020 to 2044 would be 3 to 10 percent less than the Proposed Action	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Terrestrial wildlife impacts would be analyzed in a subsequent NEPA action.	From 4,998 to 5,527 acres of shrubland and woodland vegetation at NGS and Kayenta Mine would not be removed by coal mining. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative.

Table ES-3 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.10 Terrestrial Wildlife (continued)	at the proposed KMC (traffic, lighting, noise). The WTS and STS would continue operations as described under the Air Quality Proposed Action. Moderate cumulative impacts due to regional habitat removal, foreseeable construction near the WTS.	because less coal would be mined. Direct animal losses and human activity levels would be the same as the Proposed Action. Moderate cumulative impacts would be slightly less than the Proposed Action because of reduced mining surface disturbance (see Vegetation).	because less coal would be mined. Direct animal losses and human activity levels would be the same as the Proposed Action. Moderate cumulative impacts would be slightly less than the Proposed Action because of reduce mining surface disturbance (see Vegetation).	Moderate habitat removal impacts from 2020 to 2044 would be 2 to 7 percent less than the Proposed Action because less coal would be mined. Direct animal losses and human activity levels would be the same as the Proposed Action. Moderate cumulative impacts would be slightly less than the Proposed Action because of reduce mining surface disturbance (see Vegetation).	
3.11 Special Status Wildlife Resources	Minor project impacts to individuals of the Mexican spotted owl from mining-related noise and lighting; minor impacts to Mojave and Sonoran desert tortoise from vehicle collisions during WTS and STS O&M activities. The WTS and STS would continue operations as described under the Air Quality Proposed Action. Cumulative effects minor to moderate on Mojave desert tortoise, southwest willow flycatcher, and yellow-billed cuckoo due to foreseeable transmission line and water	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Minor project impacts to special status species, same as Proposed Action. Cumulative impacts to the Mexican Spotted Owl, Mojave Desert Tortoise, Southwestern Willow Flycatcher, and yellow-billed Cuckoo would be same as the Proposed Action.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Minor project impacts to special status species, same as Proposed Action. Cumulative impacts to the Mexican Spotted Owl, Mojave Desert Tortoise, Southwestern Willow Flycatcher, and yellow-billed Cuckoo would be same as the Proposed Action.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Special status wildlife impacts would be analyzed in a subsequent NEPA action. Minor project impacts to special status species, same as Proposed Action. Cumulative impacts to the Mexican Spotted Owl, Mojave Desert Tortoise, Southwestern Willow Flycatcher, and yellow-billed Cuckoo would be same as the Proposed Action.	From 4,998 to 5,527 acres of shrubland and woodland vegetation at NGS and Kayenta mine would not be removed by coal mining, resulting in lower human activity impacts on the Mexican spotted owl. Vehicle collisions risk for Mojave and Sonoran Desert Tortoise would be same because foreseeable construction projects adjacent to the WTS would likely occur; Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative. O&M activities along the WTS and STS would continue, unless full decommissioning occurs.

Table ES-3 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
	pipeline construction.				
3.12 Aquatic Biological Resources	Minor to negligible NGS trace metal deposition impacts on aquatic community constituents and water quality. The combination of baseline concentrations with very small project contributions would result in a minor risk of selenium effects on fish populations in the San Juan River and the Colorado River below Glen Canyon Dam. Minor impacts to aquatic species due to elevated metals concentrations that exceed toxicity thresholds in proposed KMC surface waterbodies, primarily from background sources. Groundwater pumping for the proposed KMC Proposed Action would contribute less than 1 percent reduction in Begashibito Wash, resulting in minor changes in aquatic habitat where surface flows are present. The WTS and STS would continue operations as described under the Air Quality Proposed Action.	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. NGS trace metal impacts would be the same as the Proposed Action, except NGS stack emissions would be 5 to 19 percent less. Cumulative impacts from trace metals deposition, and cumulative groundwater pumping impacts on aquatic habitats would be the same as the Proposed Action.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. NGS trace metal impacts on fisheries would be the same as the Proposed Action, except NGS stack emissions would be 3 to 11 percent less. Cumulative impacts from trace metals deposition, and cumulative groundwater pumping impacts on aquatic habitats would be the same as the Proposed Action.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Aquatic biological resource impacts would be analyzed in a subsequent NEPA action. NGS trace metal impacts on fisheries would be the same as the Proposed Action, except NGS stack emissions would be 2 to 8 percent less. Cumulative impacts from trace metals deposition, and cumulative groundwater pumping impacts on aquatic habitats would be the same as the Proposed Action.	The elimination of current NGS emissions would subtract a very small emission level from existing baseline conditions. There would be continued minor deposition impacts from mercury and selenium in the Colorado River below Glen Canyon Dam, and selenium in the San Juan River on some nongame fish species. Because the elimination of emission effects from the proposed KMC facilities would be very small, the resulting metal concentrations in waterbodies would be negligible. Continued minor impacts to aquatic species due to elevated metals concentrations that exceed toxicity thresholds in Kayenta Mine surface waterbodies, primarily from background sources. Community pumping would result in base flow reductions of approximately 8 to 22 percent in Polacca, Chinle, and Begashibito washes and Laguna Creek, which would cause moderate reductions in aquatic habitat and aquatic invertebrates where surface water is present. Impacts to the WTS and STS are

Table ES-3 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.12 Aquatic Biological Resources (continued)	NGS future operations would contribute a small fraction of the total cumulative fish tissue concentrations. Cumulative deposition of mercury and selenium in the Colorado River below Glen Canyon Dam and in the San Juan River present a potential risk to fish populations. Global and other regional sources are the main contributors to metal effects.				the same as described for the Air Quality No Action Alternative.
3.13 Special Status Aquatic Biological Species	Minor trace metal deposition impacts based on the low number of fish that could be injured and the small percentage of fish population numbers potentially affected. Minor project impacts (measured by tissue concentrations) to fish individuals of Colorado pike minnow, razorback sucker, and humpback chub from NGS trace metal contributions combined with baseline concentrations. Minor impacts on critical habitat for Colorado pikeminnow and razorback sucker in the San Juan River and humpback chub and razorback sucker in the Colorado River below Glen Canyon Dam, because of historical small baseline exceedances of mercury and	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. NGS trace metal impacts would be the same as the Proposed Action, except NGS stack emissions would be 5 to19 percent less. Cumulative impacts from trace metals deposition would be nearly the same as the Proposed Action.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. NGS trace metal impacts would be the same as the Proposed Action, except NGS stack emissions would be 3 to 11 percent less. Cumulative impacts from trace metals deposition would be nearly the same as the Proposed Action.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Special status aquatic biological resource impacts would be analyzed in a subsequent NEPA action. NGS trace metal impacts would be the same as the Proposed Action, except NGS stack emissions would be 2 to 8 percent less. Cumulative impacts from trace metals deposition would be nearly the same as the Proposed Action.	Elimination of current NGS emissions after 2019 would subtract a very small emission level from existing baseline conditions. Potential risks to special status species would occur in the Colorado River below Glen Canyon Dam and San Juan River due to baseline fish tissue concentrations. There would be a minor effect on the water element of critical habitat for humpback chub and razorback sucker in the Colorado River below Glen Canyon Dam and Colorado pikeminnow and razorback sucker in the San Juan River, based on historical exceedances of mercury or selenium water quality standards. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative.

Table ES-3 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.13 Special Status Aquatic Biological Species (continued)	selenium water quality standards. The WTS and STS would continue operations as described under the Air Quality Proposed Action. Minor cumulative impacts (based on life stage injury estimates) of mercury to individuals of Colorado pikeminnow in the San Juan River; moderate impacts of mercury on humpback chub individuals and critical habitat in the Colorado River below Glen Canyon Dam; moderate impacts to razorback sucker individuals and critical habitat in the Colorado River below Glen Canyon Dam and in the San Juan River. Project emissions contributions to mercury concentrations in fish tissue are estimated to be 0.1 to 0.2 percent.				
3.14 Land Use	Moderate project land use impacts, almost entirely from continued mining on proposed KMC. Vegetation removal impacts from 2020 to 2044 would range from 4,998 to 5,527 acres. Area of surface disturbance requiring reclamation after 2044 is 10,123 acres. Disturbed areas	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate project land use impacts would be the same as the Proposed Action except that 5 to 18 percent less	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate project land use impacts would be the same as the Proposed Action except that 3 to 10 percent less	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Land use impacts would be analyzed in a subsequent NEPA action.	From 4,998 to 5,527 acres of shrubland and woodland vegetation at NGS and Kayenta Mine would not be removed by coal mining, and would be available for grazing and other uses. Once decommissioning and reclamation activities are complete after 2019, the NGS site, BM&LP Railroad ROW, and

Table ES-3 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.14 Land Use (continued)	would be reseeded with approved mixtures, and monitored for release back to the Navajo Nation and Hopi Tribe. Incremental reduction or removal of four to five grazing areas would reduce livestock grazing capacity. Residential relocations from mining areas would be a moderate impact because the residents are compensated.	surface disturbance at the proposed KMC would occur because less coal would be mined, which may change number of residents that would require relocation.	surface disturbance at the proposed KMC would occur because less coal would be mined, which may change number of residents that would require relocation.	Moderate project land use impacts would be the same as the Proposed Action except that 2 to 7 percent less surface disturbance at the proposed KMC would occur because less coal would be mined, which may change number of residents that would require relocation.	Kayenta Mine would be returned to the Navajo Nation and Hopi Tribe. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative.
3.15 Public Safety	Minor to negligible project public safety impacts because the public is excluded from the industrial activity areas of the NGS and the proposed KMC. Residents within the proposed KMC lease boundary would be exposed to equipment noise, periodic blasting, mine traffic, and potential hazardous spills Planning and implementation of best management practices would reduce impacts from potential spills. Notice of blasting activity is provided in advance and residential relocation programs are initiated when mining encroaches within the safety zone around residences. The WTS and STS would continue operations as described under the	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Minor to negligible project public safety impacts would be the same as the Proposed Action except that 5 to 18 percent less surface disturbance at proposed KMC would occur because less coal would be mined, which may change the number of residents that would require relocation, and change the residence exposure distance to potential spills, noise and fugitive dust sources.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Minor to negligible project public safety impacts would be the same as the Proposed Action except that 3 to 10 percent less surface disturbance at proposed KMC would occur because less coal would be mined, which may change the number of residents that would require relocation, and change the residence exposure distance to potential spills, noise and fugitive dust sources.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Public safety impacts would be analyzed in a subsequent NEPA action. Minor to negligible project public safety impacts would be the same as the Proposed Action except that 2 to 7 percent less surface disturbance at proposed KMC would occur because less coal would be mined, which may change the number of residents that would require relocation, and change the residence exposure distance to potential spills, noise and fugitive dust sources.	Mine reclamation activities would continue after 2019, but no active surface mining. Residential relocations, noise disturbance, and other impacts as described in the Proposed Action and action alternatives in the proposed mining areas would not occur.

Table ES-3 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
	Air Quality Proposed Action.				
3.16 Public Health and Human Health Risk	Human health risks from project component emissions are negligible because potential cancer and non-cancer risks are considered acceptable based on human health risk assessments. Project operations would result in minor or negligible health impacts to the general population. Major project benefits to public health result from long-term employment at NGS and the proposed KMC and opportunities for health care. These benefits are offset by minor emotional stress caused by relocation of residents and the indirect health effects associated with proximity to mining noise and equipment activity. The WTS and STS would continue operations as described under the Air Quality Proposed Action. Based on an unacceptable non-cancer hazard of 2 for the ingestion of Lake Powell fish by the recreational user, a minor impact on human health was identified. The impact is	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Negligible project human health risks and minor to negligible health impacts would be the same as the Proposed Action except that 5 to 18 percent less surface disturbance would occur because of less coal mining, resulting in less exposure to fugitive dust over the long term. Minor Lake Powell fish ingestion hazards would be the same as the Proposed Action.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Negligible project human health risks and minor to negligible health impacts would be the same as the Proposed Action except that 3 to 10 percent less surface disturbance would occur because of less coal mining, resulting in less exposure to fugitive dust over the long term. Minor Lake Powell fish ingestion hazards would be the same as the Proposed Action.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Impacts to public health and human health risks would be analyzed in a subsequent NEPA action. Negligible project human health risks and minor to negligible health impacts would be the same as the Proposed Action except that 2 to 7 percent less surface disturbance would occur because of less coal mining, resulting in less exposure to fugitive dust over the long term. Minor Lake Powell fish ingestion hazards would be the same as the Proposed Action.	Human exposure to NGS stack emissions would cease after 2019. Dust emissions from decommissioning and reclamation activities at NGS would occur over a 1-year period, and over a minimum of 10 years at the Kayenta Mine, a negligible human health impact. Closure of the Kayenta Mine after 2019 would eliminate public exposure to mine traffic, equipment noise, and blasting. The loss of jobs at both NGS and the Kayenta Mine would result in increased stress for unemployed workers and their families and potential loss of health benefits. This constitutes a major impact on public health. Minor Lake Powell fish ingestion hazards would be the same as the Proposed Action. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative.

Table ES-3 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.16 Public Health and Human Health Risk (continued)	considered minor because of the fish advisory (Arizona Game and Fish Department 2012) that likely limits the consumption of fish. NGS trace metal contributions to this hazard would be negligible.				
3.17 Cultural Resources	Major to negligible impacts to cultural resources from surface mining at the proposed KMC. Moderate to major impacts from discovery and repatriation of human burials within areas to be mined; moderate impacts to archeological and architectural sites; negligible to major impacts to Traditional Cultural Properties, which are places important for traditional uses or religious values. Cultural resources potentially directly affected consist of 195 to 214 archaeological sites. 15 Traditional Cultural Properties; and 13 human remains. Two Programmatic Agreements developed for the NGS-KMC Project address cultural resource impacts for all project components and direct the responsible federal agencies to consult with federal, state, Tribal, municipal, and private landowners to address Section 106 requirements.	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Major to negligible impacts to cultural resources from surface mining at proposed KMC. Direct impacts to cultural resources would be similar to the Proposed Action, but cannot be quantified because specific future mining plans have not yet been developed. Negligible to major cumulative risks for cultural resource disturbance from foreseeable utility construction activities adjacent to, or near the WTS ROW.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Major to negligible impacts to cultural resources from surface mining at the proposed KMC. Direct impacts to cultural resources would be similar to the Proposed Action, but cannot be quantified because specific future mining plans have not yet been developed. Negligible to major cumulative risks for cultural resource disturbance from foreseeable utility construction activities adjacent to, or near the WTS ROW.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Cultural resource impacts would be analyzed in a subsequent NEPA action. Major to negligible impacts to cultural resources from surface mining at the proposed KMC. Direct impacts to cultural resources would be similar to the Proposed Action, but cannot be quantified because specific future mining plans have not yet been developed. Negligible to major cumulative risks for cultural resource disturbance from foreseeable utility construction activities adjacent to, or near the WTS ROW.	Project impacts to historic properties listed in or potentially eligible for listing in the NRHP would not occur. Potential impacts to cultural resources of any type would take place during the decommissioning phase of the project. Any future undertakings, such as decommissioning and reclamation, would be addressed through the standard regulatory process (36 CFR 800) by the appropriate federal agency. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative.

Table ES-3 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.17 Cultural Resources (continued)	The WTS and STS would continue operations as described under the Air Quality Proposed Action. Negligible to major cumulative risks for cultural resource disturbance from foreseeable utility construction activities adjacent to or near the WTS ROW.				
3.18 Socio-economics	Major economic impacts are associated with the continuation of the NGS-KMC Project. These include providing 2,745 to 3,812 jobs, approximately 187 to 260 million dollars in labor income, and estimated project-related payments to tribes of 1.8 to 2.5 billion over the 25-year period. A continued employment base would provide long-term social stability, and allow the younger generation members to remain in their communities. Concerns about the long-term commitment to coal as a source of electrical energy, public health, water supply availability, residential relocations, and grazing land availability would continue.	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Major economic impacts are associated with continuation of the NGS-KMC Project. NGS and proposed KMC employment and labor income would be between 4 and 10 percent lower compared to the Proposed Action. These labor income and employment reductions would be major impacts because of the lack of revenue replacement opportunities. Project operations would provide long-term social stability, and concerns about commitment to coal as an energy source, and impacts to public health and land use	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Major economic impacts are associated with continuation of the NGS-KMC Project. NGS and proposed KMC employment and labor income would be between 3 and 6 percent lower compared to the Proposed Action. These labor income and employment reductions would be major impacts because of the lack of revenue replacement opportunities. Project operations would provide long-term social stability, and concerns about commitment to coal as an energy source, and impacts to public health and land use	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Socioeconomic impacts would be analyzed in a subsequent NEPA action. Major economic impacts are associated with continuation of the NGS-KMC Project. NGS employment and labor income would be between 3 and 7 percent lower compared to the Proposed Action. These labor income and employment reductions would be major impacts because of the lack of revenue replacement opportunities. Short-term employment (1 to 3 years) providing 550 to 650 construction jobs would provide a minor income and	Major economic and social impacts would occur if NGS and the Kayenta Mine ceased operations after 2019. It is estimated that 3,090 jobs would be immediately lost, with a reduction in labor income of $234 million per year, as well as long-term retirement and pension income. Community contributions and scholarships provided by NGS and Kayenta Mine operators of approximately $700,000 per year; payments to the Navajo electrical utility; and PWCC contributions to abandoned mine and black lung funds would cease. Fiscal impacts would be major because of the very large contribution of NGS and the Kayenta Mine to the Navajo and Hopi government revenues, and the high proportion of tribal

Table ES-3 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.18 Socio-economics (continued)	The WTS and STS would continue operations as described under the Air Quality Proposed Action. Pumping energy costs to CAP are expected to increase by 20 to 23 percent, as compared to 2016 base rate of $76 per acre-foot of water delivered (Agricultural Settlement Pool). This increase is considered a minor to moderate impact to agricultural water users. The contributions of the project to cumulative socioeconomic effects would be moderate to major because the incomes for residents and payments to the Navajo Nation and Hopi are substantial and would provide a measure of revenue stability at a time when revenues from other sources may decline.	would continue. Pumping energy costs to CAP would increase by between 45 and 112 percent as compared to 2016 base rate of $76 per acre-foot of water delivered (Agricultural Settlement Pool). This increase is considered a moderate to major impact to users. The contributions of the project to cumulative socioeconomic impacts would be moderate to major, same as the Proposed Action.	would continue. Pumping energy costs to CAP would increase by between 36 and 68 percent as compared to 2016 base rate of $76 per acre-foot of water (Agricultural Settlement Pool). This increase is considered a minor to major impact to users. The contributions of the project to cumulative socioeconomic impacts would be moderate to major, same as the Proposed Action.	employment benefit. Project operations would provide long-term social stability, and concerns about commitment to coal as an energy source, and impacts to public health, cultural resources, and land use would continue. Pumping energy costs to CAP would increase by between 36 and 68 percent as compared to 2016 base rate of $76 per acre-foot of water delivered (Agricultural Settlement Pool). This increase is considered a minor to major impact to users. The contributions of the project to cumulative socioeconomic impacts would be moderate to major, same as the Proposed Action.	workers at both facilities. Rising unemployment would likely require many workers and their families to leave Page, Kayenta, and other nearby Navajo chapters for employment opportunities elsewhere. Economic hardship for local business would likely increase from the loss of power plant and mine employment. Project-related concerns about public health, cultural resources, and land use would diminish. Pumping energy costs to CAP could result in energy costs between 19 percent lower and 18 percent more costly as compared to 2016 base rate of $76 per acre-foot of water delivered (Agricultural Settlement Pool). This range is largely dictated by changes in natural gas prices. Costs of agricultural production may increase, resulting in less income to farmers. No excess generation income would be provided by NGS, and therefore no contributions to the Development Fund. Impacts to the WTS and STS are the same as described for the Air

Table ES-3 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
					Quality No Action Alternative.
3.19 Environmental Justice	Residents living within and immediately adjacent to the proposed KMC who are part of the Environmental Justice population on the Navajo Nation would experience disproportionately high sociocultural impacts and minor to moderate human health impacts. No disproportionately high and adverse sociocultural or human health impacts to any other environmental justice populations would be anticipated. The WTS and STS would continue operations as described under the Air Quality Proposed Action. No disproportionately high and adverse air quality, water resources, ecological, or safety impacts to any environmental justice population would be anticipated.	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Environmental justice impacts would be the same as the Proposed Action.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Environmental justice impacts would be the same as the Proposed Action.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Environmental Justice issues would be analyzed in a subsequent NEPA action. Environmental justice impacts would be the same as the Proposed Action.	Major economic and social impacts including the loss of over 3,000 total jobs, many of which are currently held by Navajo and Hopi workers. The loss of revenues from NGS and the Kayenta Mine to the Navajo Nation and Hopi Tribe would reduce services and employment on the two reservations that would represent a major, long-term impact for the two tribes. Employment losses would have corresponding social effects and potentially result in relocation for affected Navajo and Hopi families or wage earners. These economic and social impacts would be considered major, and they would accrue disproportionately to the Navajo Nation and Hopi Tribe, which are environmental justice populations identified for this EIS.

Table ES-3 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.20 Indian Trust Assets	Minor to negligible impacts would be anticipated to Navajo Nation and Hopi Tribe Indian trust assets. The impacts on land, water, and mineral trust assets would be offset by the negotiated compensations and protection measures provided by lease and ROW agreements, environmental regulations, plans, and programs (e.g., Coal Combustion Residuals Rule, Groundwater Protection Plan), No impacts to land trust assets of the Kaibab Band of Paiute Indians or Moapa Band of Paiute Indians related to the transmission systems and communication sites. The WTS and STS would continue operations as described under the Air Quality Proposed Action. No impact on water rights trust assets for the CAP-affected tribes. Higher energy costs for pumping CAP water and associated effects of higher costs on deposits to the Development Fund could affect economics of CAP water utilization for some CAP-	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Project impacts on Indian trust assets for the Navajo Nation, Hopi Tribe, Kaibab Band of Paiute Indians, and Moapa Band of Paiute Indians would be the same as the Proposed Action. No impact on water rights Indian trust assets for the CAP-affected tribes (same as the Proposed Action). Pumping energy costs could be higher or lower than those under the Proposed Action, depending on the future price of natural gas. This potentially could affect deposits to the Development Fund and the economics of CAP water utilization for some CAP-affected tribes.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Project impacts on Indian trust assets for the Navajo Nation, Hopi Tribe, Kaibab Band of Paiute Indians, and Moapa Band of Paiute Indians would be the same as the Proposed Action. No impact on water rights Indian trust assets for the CAP-affected tribes (same as the Proposed Action). Pumping energy costs would be higher than those under the Proposed Action, depending on the future price of natural gas. This potentially could affect deposits to the Development Fund and the economics of CAP water utilization for some CAP-affected tribes.	The Tribal PFR Alternative assumes a new, but unidentified site(s) between 3,000 and 1,200 acres on tribal lands. The affected tribe would receive financial compensation and could negotiate for other measures to address impacts on Indian trust assets. Site-specific impacts on Indian trust assets would be analyzed in a subsequent NEPA action. Project impacts of NGS, the proposed KMC, transmission systems, and communications sites on Indian trust assets for the Navajo Nation, Hopi Tribe, Kaibab Band of Paiute Indians, and Moapa Band of Paiute Indians would be the same as the Proposed Action. No impact on water rights Indian trust assets for the CAP-affected tribes (same as the Proposed Action). Pumping energy costs would be higher than those under the Proposed Action, potentially affecting deposits to the Development Fund and the economics of CAP	No negative impacts to Indian trust assets of the Navajo Nation or Hopi Tribe would be anticipated. However, payments from 2020 to 2044 from NGS (totaling $793 million to $1.07 billion to the Navajo Nation) and from the proposed KMC (combined total to the Navajo Nation and Hopi Tribe from $787 million to $1.16 billion) for the use of water, land, and mineral Indian trust assets would be foregone compared to the Proposed Action. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative. No impacts from continued operations and maintenance of the WTS, STS, and communications sites to Indian trust land assets of the Kaibab Band of Paiute Indians or Moapa Band of Paiute Indians. No impact on water rights Indian trust assets for the CAP-affected tribes (same as the Proposed Action). Pumping energy costs for CAP water under No Action could result in energy costs of between

Table ES-3 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.20 Indian Trust Assets (continued)	affected tribes.			water utilization for some CAP-affected tribes.	23 percent lower and 21 percent higher than under the Proposed Action, depending on the future price of natural gas. Deposits into the Development Fund would cease. The effects could affect the economics of CAP water utilization for some CAP-affected tribes.

Chapter 1.0

Purpose and Need for the Proposed Action

Acronyms and Abbreviations

1969 Lease	Navajo Project Indenture of Lease
BART	Best Available Retrofit Technology
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BM&LP Railroad	Black Mesa & Lake Powell Railroad
BO	Biological Opinion
CAP	Central Arizona Project
CEQ	Council on Environmental Quality
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
CO_2	carbon dioxide
Co-tenants	Salt River Project, Arizona Public Service, NV Energy, and Tucson Electric Power Company
Development Fund	Lower Colorado River Basin Development Fund
EIS	Environmental Impact Statement
ERA	Ecological Risk Assessment
ESA	Endangered Species Act of 1973
HHRA	Human Health Risk Assessment
km	kilometer
KMC	Kayenta Mine Complex
kV	kilovolt
kW	kilowatt
MW	megawatt
N-Aquifer	Navajo Aquifer
NEPA	National Environmental Policy Act of 1969, as amended
NGS	Navajo Generating Station
NGS Participants	U.S. (Reclamation), Salt River Project, Arizona Public Service, NV Energy, and Tucson Electric Power Company
NHPA	National Historic Preservation Act
NNEPA	Navajo Nation Environmental Protection Agency
NO_2	nitrogen dioxide
NO_X	nitrogen oxide
OSMRE	Office of Surface Mining Reclamation and Enforcement
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter of 10 microns or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 microns or less
PFR	Partial Federal Replacement
PWCC	Peabody Western Coal Company
Reclamation	U.S. Bureau of Reclamation
ROW	Right-of-way
SMCRA	Surface Mining Control and Reclamation Act of 1977
SO_2	sulfur dioxide

SRP	Salt River Project Agricultural Improvement and Power District
STS	Southern Transmission System
U.S.	United States
USC	United States Code
USEPA	U.S. Environmental Protection Agency
WTS	Western Transmission System

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1.0 Purpose and Need for the Proposed Action

1.1 Introduction

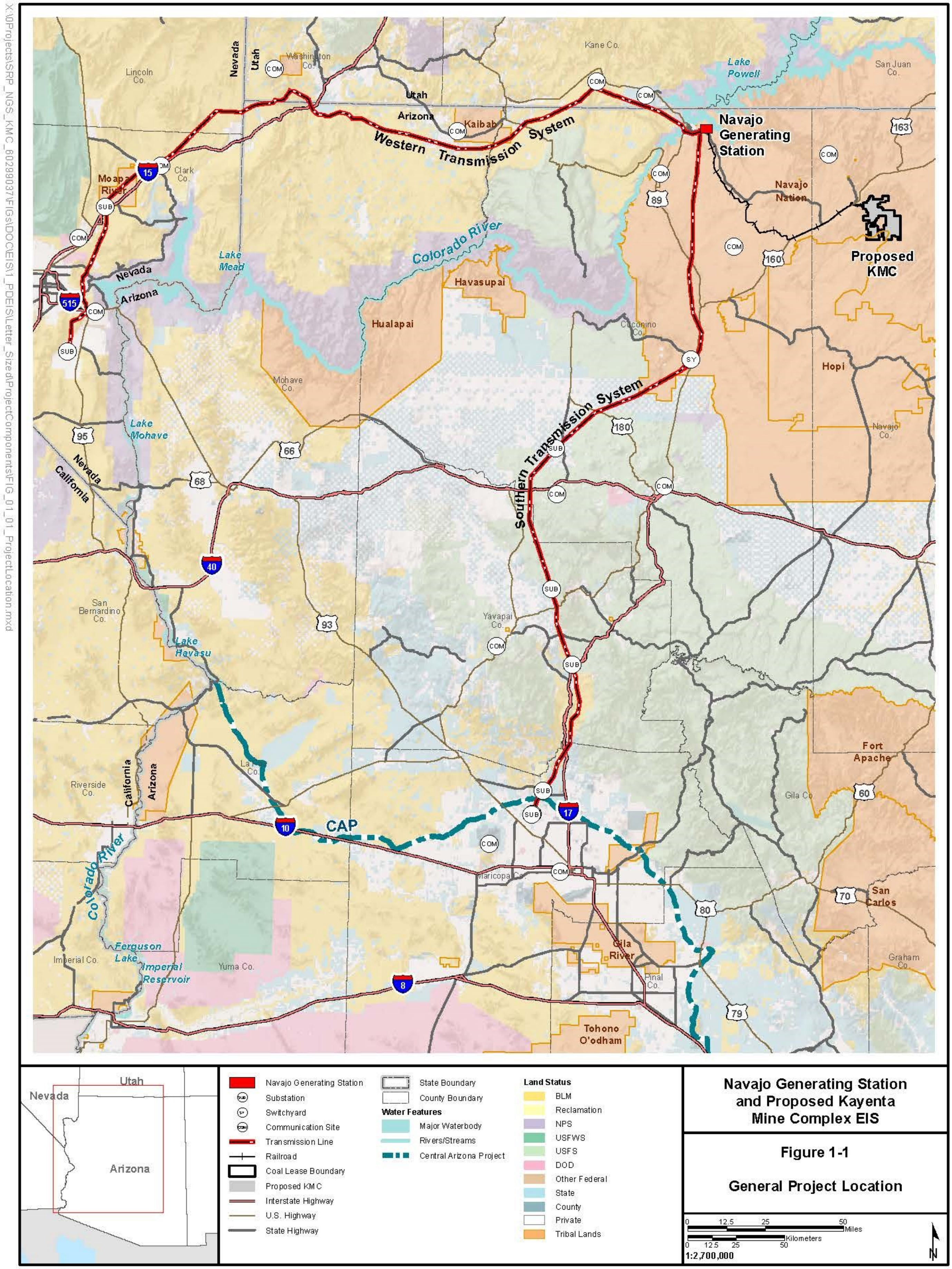
This Draft Environmental Impact Statement (EIS) describes the potential environmental impacts from the proposed continued operations of the Navajo Generating Station (NGS) and Kayenta Mine (**Figure 1-1**) for an additional 25 years, from December 23, 2019, through December 22, 2044, plus sufficient time for decommissioning of the NGS plant and its associated facilities and reclamation of the proposed Kayenta Mine Complex (KMC) (the Proposed Action). The lease under which NGS currently operates will expire on December 22, 2019.

The EIS evaluates the environmental effects of the Proposed Action, three action alternatives, and a No Action Alternative. It has been prepared in compliance with the requirements of the National Environmental Policy Act of 1969, as amended (NEPA) (Public Law 91-190), Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 Code of Federal Regulations [CFR] Parts 1500-1508), and U.S. Department of the Interior regulations implementing NEPA (43 CFR Part 46).

The United States (U.S.) Department of the Interior's Bureau of Reclamation (Reclamation) is the lead federal agency for purposes of complying with NEPA, Section 7 of the Endangered Species Act (ESA), and Section 106 of the National Historic Preservation Act (NHPA). Due to the substantial jurisdictional responsibilities of both the Office of Surface Mining Reclamation and Enforcement (OSMRE) and Bureau of Indian Affairs (BIA), these two agencies have been defined as a "key cooperating agency;" Reclamation has worked closely with both OSMRE and BIA in preparing this Draft EIS (see Section 1.5.1 for additional explanation regarding these agencies' roles and responsibilities).

The project area for the Proposed Action encompasses a large area of northern Arizona, with other portions falling within southern Nevada, southwestern Utah, and central Arizona (**Figure 1-1**). There are three major components that make up the project area. These are the NGS and associated facilities, the proposed KMC, and the Western and Southern Transmission Systems (WTS and STS, respectively).

NGS is an existing 2,250-megawatt (MW) coal-fired power plant located on leased Navajo Nation Tribal Trust Lands about 5 miles east of Page, Arizona. Construction of the facility began in 1969 and power production started in 1973. NGS provides baseload power to over 1 million customers in Arizona, California, and Nevada. NGS also provides over 90 percent of the power used by the Central Arizona Project (CAP), a federal project that delivers approximately 1.5 million acre-feet annually of Colorado River water from a diversion point in Lake Havasu near Parker, Arizona, to central Arizona. Colorado River water delivered via the CAP serves tribal, agricultural, municipal, and industrial water users in Maricopa, Pinal, and Pima counties, Arizona.



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 1-1

General Project Location

The Salt River Project Agricultural Improvement and Power District (SRP) is the operating agent of the NGS and holds a 21.7 percent ownership interest in the NGS on its own behalf. SRP also purchased the 21.2 percent interest in NGS, through 2019, that was formerly held by the Los Angeles Department of Water and Power.[1] Pursuant to an agreement with the U.S., SRP also holds a 24.3 percent interest in the NGS for the use and benefit of the U.S., which is used to operate the CAP. SRP, Arizona Public Service, NV Energy, and Tucson Electric Power Company are NGS Co-tenants. Altogether, with the U.S., the five entities collectively are referred to as the "NGS Participants." The current NGS Participants and interest percentages are displayed in **Figure 1-2**. The NGS includes three 750-MW electric generating units that produce up to 2,250 MW of net output. The U.S. share of NGS power at full output is 546.7 (547) MW.

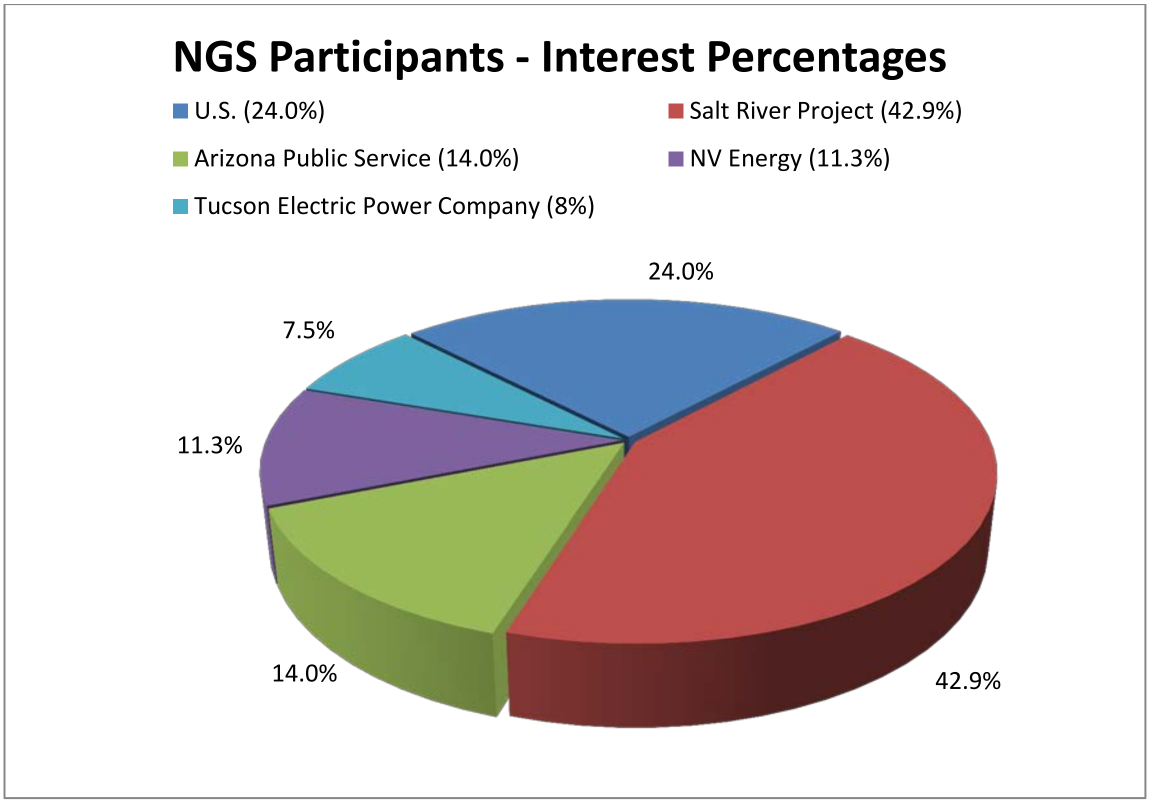
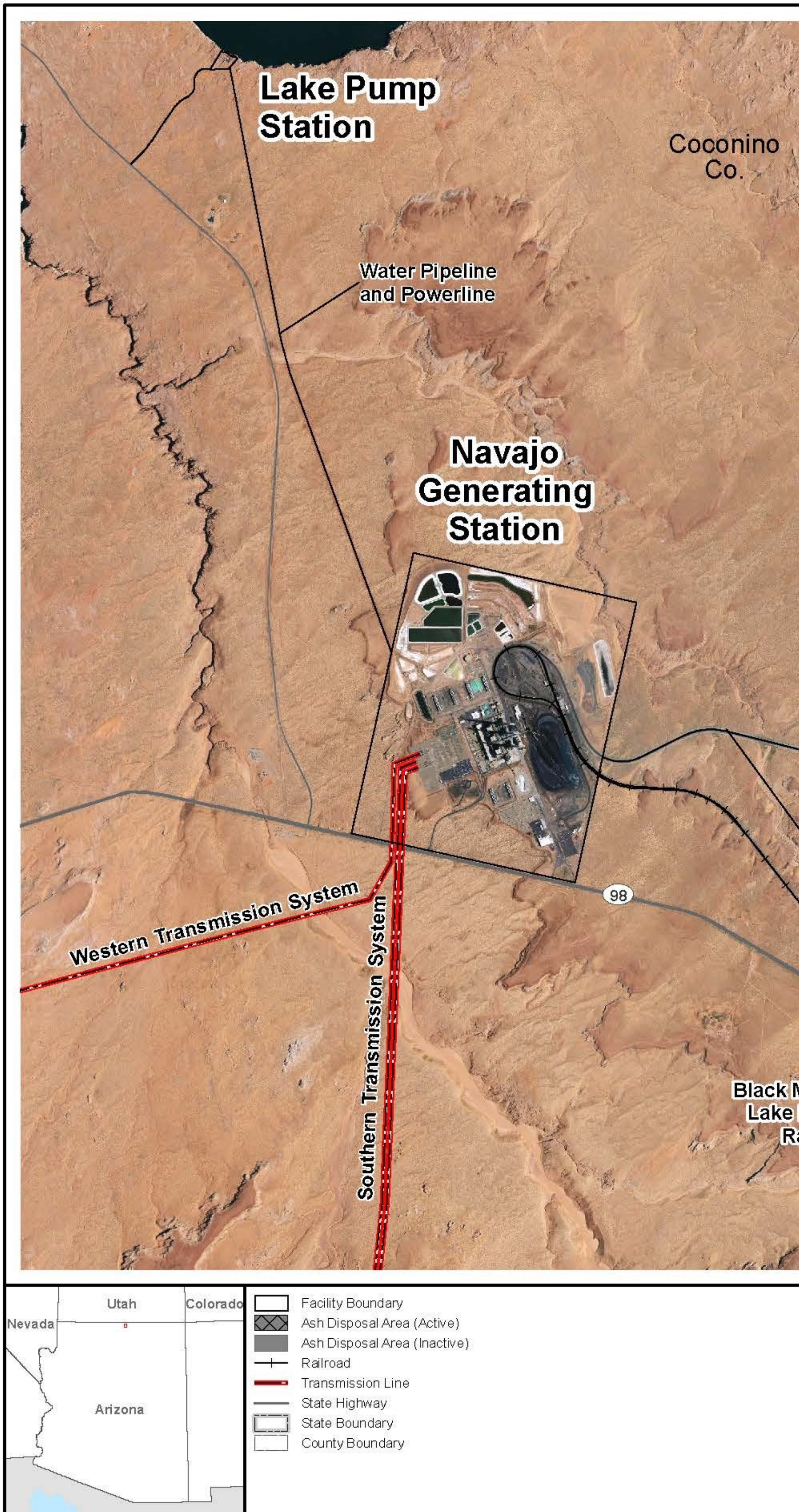


Figure 1-2 NGS Participants' Interest Percentages

Facilities associated with the NGS include a water supply system from Lake Powell; coal-fired boilers; steam turbine generators; water treatment facilities; air pollution control systems; waste management facilities including landfills; transformers; switchyards; substations; roads; communication sites; and administration, operation, maintenance, and warehouse facilities. There also is the approximately 78-mile electric Black Mesa & Lake Powell (BM&LP) Railroad plus a 2-mile railroad turn-around loop and coal-handling facilities at the railroad-terminus at the plant. The features of NGS and its associated facilities are described in Section 1.7.1. An overview of NGS facilities is shown in **Figure 1-3**.

[1] On July 1, 2016, Los Angeles Department of Water and Power executed an asset purchase agreement with SRP wherein SRP acquired Los Angeles Department of Water and Power's share of NGS generation through 2019. Los Angeles Department of Water and Power intends to continue to participate in the NGS transmission system and is referred to in this document as an NGS Transmission-Only Participant. See Section 1.8.3 for additional information.



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 1-3
Navajo Generating Station Facilities

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The fuel supply for the three generating units is low sulfur bituminous coal transported by the BM&LP Railroad to NGS from the Kayenta Mine. Kayenta Mine is owned and operated by the Peabody Energy subsidiary, Peabody Western Coal Company (PWCC). On April 13, 2016, Peabody Energy and the majority of its U.S. subsidiaries, including PWCC, voluntarily filed petitions to reorganize under Chapter 11 of the U.S. Bankruptcy Code in the U.S. Bankruptcy Court for the Eastern District of Missouri. The bankruptcy court filings state that Peabody and its subsidiaries expect to emerge from bankruptcy in or about April 2017. During the bankruptcy, mining and reclamation activities are continuing and are expected to continue in a business-as-usual fashion at the Kayenta Mine. During and after the bankruptcy, PWCC and any reorganized entity, must still comply with all applicable laws, including federal, state, and Tribal environmental laws, as well as the terms and conditions of the mine leases.

The Kayenta Mine is located about 78 miles southeast of NGS on Navajo Nation and Hopi Tribal Trust Lands near Kayenta, Arizona (**Figure 1-1**).The Kayenta Mine is the sole commercial supplier of coal used by the NGS, and the NGS is the sole commercial customer of coal produced at the Kayenta Mine.

The entire mining leasehold is composed of contiguous mining leases and several surface rights-of-way (ROWs) and easements granted to PWCC from the Navajo Nation and Hopi Tribe (**Figure 1-4**). The leases are as follows:

1. Navajo Mining Lease Number 14-20-0603-8580: Surface and mineral interest for 24,858 acres.
2. Joint Use Navajo Mining Lease Number 14-20-0603-9910: Joint mineral ownership lease area for 40,000 acres, of which the Navajo Nation holds the surface interests for 33,863 acres.
3. Joint Use Hopi Mining Lease Number 14-20-0450-5743: Joint mineral ownership lease area for 40,000 acres, of which the Hopi Tribe holds the surface interest for 6,137 acres.

In what was formerly designated the “Joint Use Area” (former Joint Use Area), the Hopi Tribe and Navajo Nation have joint and equal interest in the minerals that underlie the area; however, the surface has been partitioned and is within the exclusive jurisdiction of the tribe to which the surface is partitioned. No new federal action is proposed to be taken with respect to these three leases, and none are needed as a result of the Proposed Action; therefore, these leases are not the subject of this EIS.

Pursuant to Public Law 95-87, the Surface Mining Control and Reclamation Act of 1977 (SMCRA), PWCC operated the entire mining leasehold as two separate surface mining operations—the former Black Mesa Mine and the Kayenta Mine—under the initial and permanent regulatory programs, respectively. The former Black Mesa Mine supplied commercial coal exclusively to the Mohave Generating Station, located near Laughlin, Nevada, until the Mohave Generating Station shut down in December 2005.[2] No coal production has occurred from the former Black Mesa Mine since 2005, and none is currently planned or permitted; however, mine reclamation activities have continued at the former Black Mesa Mine.

[2] The Mohave Generating Station has since been completely dismantled, and all structures have been removed from the site except for its switchyard, transmission lines, and pumping station.

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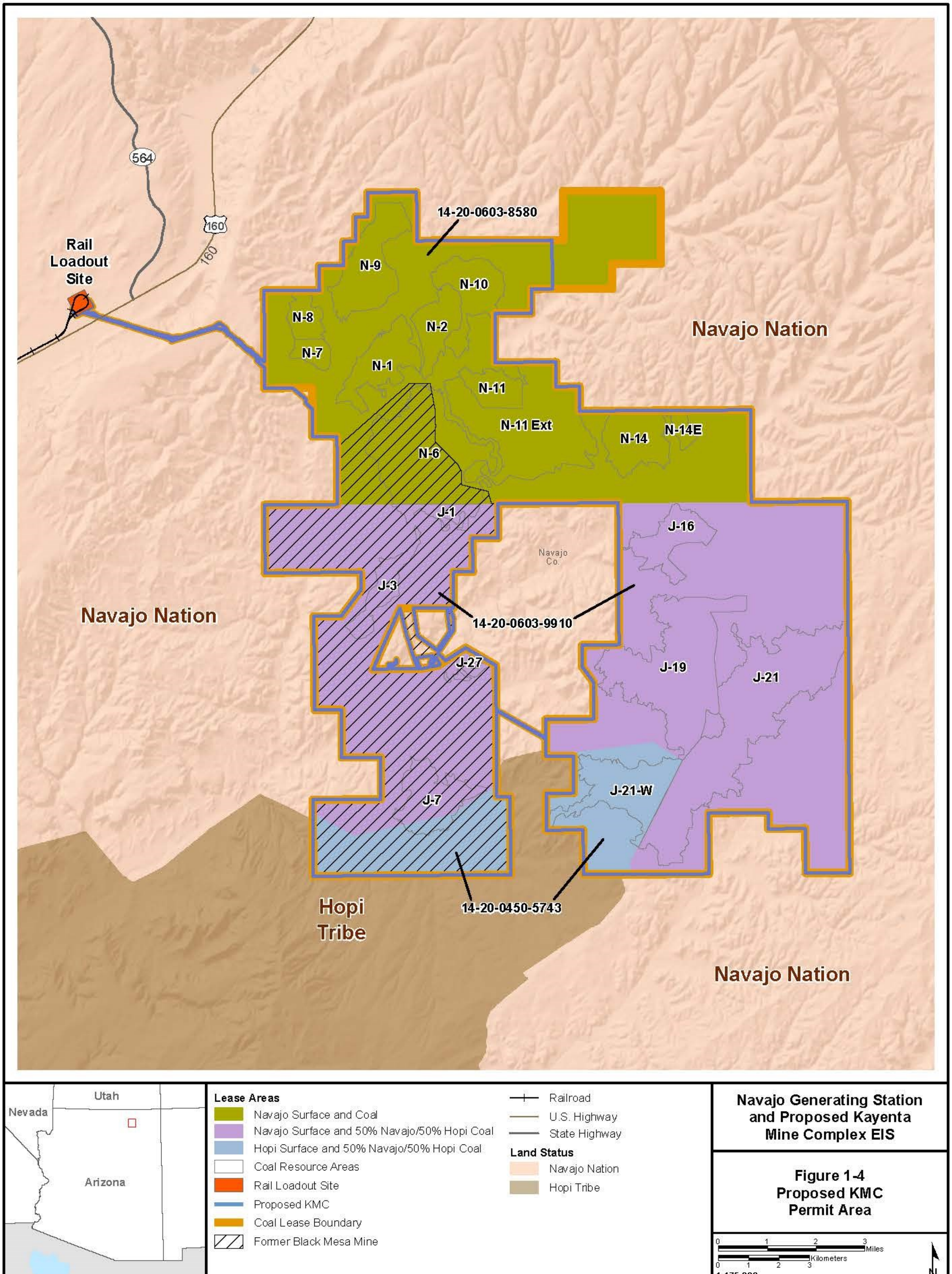

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 1-4
Proposed KMC
Permit Area

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The Kayenta Mine supplies coal to the NGS at a current production rate of about 8 million tons per year. The Kayenta mining operation uses support facilities also used by the former Black Mesa Mine and reclamation operation. This is consistent with PWCC's approved permit application package under the SMCRA (PWCC 2012 et seq.). At the current production rate, mining coal for the NGS at the Kayenta Mine could continue through 2026 under its existing SMCRA Permit and Life-of-Mine Plan.

Power is transmitted from NGS to substations near Las Vegas, Nevada, and Phoenix, Arizona, via two transmission systems known as the WTS and STS (**Figure 1-1**). These two transmission systems are operated as part of the NGS Project to provide safe and reliable power to the NGS Participants' customers, including the CAP. Both the WTS and STS are integrated in the country's western electrical grid and are used for energy transmission other than the power being generated at NGS.

The WTS consists of a 500-kilovolt (kV) transmission line that begins at NGS and heads west across northern Arizona, with two small segments crossing into Utah. The transmission line then enters Nevada and continues in a southwesterly direction toward Las Vegas, ending at the McCullough substation just outside Boulder City, Nevada. The WTS line is 275 miles long. The NGS Participants that utilize the WTS include the NV Energy, and the U.S. Los Angeles Department of Water and Power is the administrator and NV Energy is responsible for on-the-ground operation and maintenance. The STS consists of two parallel, 500-kV transmission lines, both of which begin at NGS and head south, ending at the Westwing substation, in Peoria, Arizona. The STS lines are 256 miles long and are located entirely in Arizona. All five NGS Participants, as well as Los Angeles Department of Water and Power, have an interest in all or a portion of the STS, which is operated by Arizona Public Service.

Altogether there are 8 substations/switchyards, besides the one located within the NGS plant site, and 19 communication sites that support the two transmission systems, railroad, and NGS operations.

The Proposed Action includes, but is not limited to, the following federal agency actions that would allow NGS to operate from December 23, 2019 through December 22, 2044, plus sufficient time for decommissioning of the plant and its associated facilities, and reclamation of the proposed KMC (for purposes of the EIS this period is referred to as 2020 through 2044 plus decommissioning):

1) approval and execution of an NGS plant lease amendment (or a lease agreement among the Navajo Nation and the continuing NGS Participants only, under substantively the same terms as the 1969 lease and the proposed amendment);
2) approval of new, renewed, or amended grants of ROW and easements for the NGS plant site and related facilities, including the BM&LP Railroad and the water intake facility at Lake Powell;
3) approval of new, renewed or amended ROWs and easements that support the two transmission systems used to deliver the electricity, including nine substations, and 19 communication sites;
4) negotiation and execution of a water service contract renewal for delivery of Upper Basin Colorado River water to support NGS operations through 2044 plus decommissioning;
5) approval of a permit revision application that would update the Life-of-Mine Plan and adjust the permit boundary to allow continued coal mining operations at the Kayenta Mine for the same time period, and realign Navajo Route 41; and
6) approval by the U.S., acting through Reclamation, of all contracts, easements, ROWs and other legal arrangements needed to extend the operation of NGS through the end of 2044.[3]

[3] In addition to the NGS plant site lease, the existing operation of NGS, proposed KMC, and their associated facilities are subject to complex legal arrangements and federal approvals. These arrangements, as well as any proposed extensions, modifications, or new arrangements anticipated by the Proposed Action, are described in the synopsis of NGS and KMC documents (**Appendix 1A**).

1.2 Project Location

As indicated in Section 1.1, portions of the project area are located in Arizona, Utah, and Nevada. The NGS plant site, its associated facilities, and the proposed KMC are located in the central part of northern Arizona. The WTS crosses lands in Arizona, Utah, and Nevada, while the STS extends south from the NGS to the Phoenix metropolitan area in central Arizona. The mining permit area is located on Navajo and Hopi Tribal Trust Lands. The NGS plant and associated facilities, with the exception of a small portion of the Colorado River water intake facility at Lake Powell, are located on Navajo Tribal Trust Lands. Portions of the WTS and STS also are located on Navajo Tribal Trust Lands. The remainder of the NGS-KMC Project area, consisting of the remaining portions of the WTS and STS, is located on a mix of public and private land.

Other areas impacted by the Proposed Action are discussed under the appropriate “action area” descriptions in Chapter 3.0. For example, impacts on the three-county CAP service area are addressed in Socioeconomic Resources, Section 3.18. This is because the U.S.’ share of NGS power is used to operate the pumps that deliver water to the CAP service area. Decisions made regarding the Proposed Action may affect those using CAP water, since the cost of energy to operate the CAP pumps is a major component of the cost of CAP water to its users.

1.3 Project Background

The initial apportionment of water from the Colorado River was determined as part of the Colorado River Compact of 1922, which divided the Colorado River system into two sub-basins, the Upper Basin and the Lower Basin. The Colorado River Compact of 1922 also divided the seven Colorado River Basin states into the Upper Division and the Lower Division states,[4] and apportioned to each division, in perpetuity, the exclusive beneficial consumptive use of 7.5 million acre-feet annually. Lower Division state apportionments were established by Congress in the 1928 Boulder Canyon Project Act (Public Law 70-642, 45 Statute 1057), and later confirmed by the 1963 U.S. Supreme Court opinion in *Arizona v. California* (373 U.S. 546) and subsequent Consolidated Decree (547 U.S. 150). These annual apportionments are: Arizona, 2.8 million acre-feet; California, 4.4 million acre-feet; and Nevada, 0.3 million acre-feet. Arizona also holds an Upper Basin apportionment of 50,000 acre-feet of Colorado River annually.

The 1968 Colorado River Basin Project Act (Public Law 90-537, 82 Statute 885) authorized the construction, operation, and maintenance of the CAP, which facilitates the full utilization of Arizona’s Lower Division Colorado River apportionment. It also provided the legal authority for the federal government, through the Secretary of the Interior, to enter into agreements to participate in the “Navajo Project,”[5] which generates the power and energy[6] used to operate the CAP pump stations. The Colorado River Basin Project Act states that the U.S.

> “…may enter into agreements with non-federal interests proposing to construct thermal generating power plants whereby the United States shall acquire the right to such portions of their capacity, including delivery of power and energy over appurtenant

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[4] The Upper Division states are Colorado, New Mexico, Utah, and Wyoming; the Lower Division states are Arizona, California, and Nevada.

[5] The original NGS-Kayenta Mine Project was named the “Navajo Project”; however, due to potential confusion with a recent OSMRE project called the Navajo Mine Energy Project, this document uses the term NGS Project when referring to the original “Navajo Project.”

[6] For purposes of this document, power means electrical power, which is the rate at which electrical energy is transferred, as measured in watts, kilowatts, MW; energy means electrical energy, which is the amount of power used over time, generally measured in kilowatt-hours, or MW-hours (MWh).

> transmission facilities to mutually agreed upon delivery points, as…required in connection with the operation of the Central Arizona Project."

The agreements authorized by the Colorado River Basin Project Act covered construction and operation of four major features of the NGS Project: 1) the NGS plant and associated facilities including the BM&LP Railroad that delivers coal from the Kayenta Mine to the plant site; 2) the coal supply from the Kayenta Mine, described in Section 1.7.2.1; 3) the water supply for NGS and the water intake structures (located on federal land administered by the National Park Service) used to transport Upper Basin Colorado River water for use at NGS described in Section 1.7.1.4); and 4) WTS and STS and communication sites, described in Section 1.7.3. These agreements are summarized below and described in greater detail in **Appendix 1A**.

The "Navajo Project Indenture of Lease for Navajo Units 1, 2, and 3" (1969 Lease [also referred to in this document as "Indenture of Lease for Units 1, 2, and 3"]) was dated on September 29, 1969, between the Navajo Tribe of Indians (now the Navajo Nation, which is used in the remainder of the EIS) and the NGS Co-tenants; this executed lease was approved by the Secretary of the Interior. The 1969 Lease encumbered Navajo Tribal Trust Lands used for the "Plant Site, Rail Loading Site, Ash Disposal Area, Auxiliary and Related Rights." The 1969 Lease was entered into for the plant construction "…together with transmission facilities interconnecting the electric system of Lessees and furnishing a means of transmitting power and energy for the U.S... Central Arizona Project pumping power requirements…" The 1969 Lease expires December 22, 2019. The associated BIA 323 Grant of ROW[7] issued to the NGS Co-tenants for the NGS plant site expires at the end of 2019, while the initial term of another 323 Grant for the BM&LP Railroad expires in 2021. The 1969 Lease provides an option and/or right to extend the lease for an additional 25 years, until December 22, 2044, plus decommissioning. Lease Amendment No. 1 to the 1969 Lease (Lease Amendment No.1) provides the Navajo Nation's consent to the extension of the NGS lease through 2044, plus decommissioning, and provides the Navajo Nation's consent to the issuance, renewal, and/or extension of the 323 Grants of ROWs for the plant site, railroad, transmission systems and communication sites within the Navajo Nation, as described below. The Navajo Nation Council approved the Lease Amendment No. 1 on July 17, 2013, which authorized the President of the Navajo Nation to sign the Lease Amendment No. 1. The Navajo Nation President signed Lease Amendment No. 1 on July 30, 2013, per Navajo Nation Council Resolution CJY-40-13.[8]

The WTS and STS also are supported by 323 Grants on the Navajo Reservation. Off the Navajo Reservation, these systems are supported by grants of ROW and easements issued by other federal agencies, state agencies, municipalities, and private landowners.

The Colorado River Basin Project Act also authorized the sale of surplus NGS power and energy at market rates to provide a source of revenue for the Lower Colorado River Basin Development Fund (Development Fund), which is used to assist in repayment of the CAP construction costs, stating:

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[7] Request for the BIA to grant a ROW under the terms and provisions of the Act of February 5, 1948 (Title 25 United States Code [USC] Sections 323-328) and Departmental Regulations at 25 CFR Part 169.

[8] Depending on the composition of plant ownership on December 23, 2019, the provisions of the 1969 lease and Lease Amendment No. 1 may be merged into a single, new lease among the Navajo Nation and the continuing NGS Participants only. Should this occur, authorization of the new lease, if required, would be sought and obtained from the Navajo Nation.

> "When not required for the Central Arizona Project, the power and energy acquired by such agreements may be disposed of intermittently by the Secretary…so as to produce the greatest practicable amount of power and energy that can be sold at firm power and energy rates."

Subsequent authorization was included in the Arizona Water Settlements Act of 2004 (Public Law 108-451, 118 Statute 3478) to allow the Development Fund to be used for the payment of fixed operation, maintenance, and replacement charges associated with the delivery of CAP water to Arizona Native American tribes and other statutory purposes. More information on how the Development Fund is managed is provided in Socioeconomic Resources, Section 3.18.3.3.

The Co-Tenancy Agreement for NGS, dated March 23, 1976 (Co-Tenancy Agreement) among the NGS Participants establishes the terms and conditions relating to the NGS Participants' interests in NGS and its related facilities, and establishes certain rights and obligations of the parties. The Co-Tenancy Agreement controls U.S. participation in the decisions that affect the federal interest at NGS. As provided in the Co-Tenancy Agreement, SRP must obtain the prior written consent of the U.S. for actions that would affect the interest in NGS held by SRP for the use and benefit of the U.S., including actions to extend NGS operations after 2019.

The Secretary has delegated the authority to carry out the U.S.-related aspects of the NGS contracts to Reclamation. Reclamation also serves as the contractor for the existing Water Service Contract which supplies Upper Basin Colorado River water to the NGS. Pursuant to the Colorado River Storage Project Act (Public Law 203-485, 70 Statute 105) and other federal reclamation laws, Reclamation must negotiate and approve the terms of a Water Service Contract renewal through 2044 as part of the Proposed Action.

With respect to the fuel supply for NGS from the Kayenta Mine, Sentry Royalty Company entered into a lease with the Navajo Nation in 1964 to lease a tract of land containing 24,858 acres for the purpose of surface coal mining (Mining Contract No. 14-20-0603-8580). In 1966, Sentry Royalty Company entered into leases with the Navajo Nation (Mining Contract No. 14-20-0603-9910) and Hopi Tribe (Mining Contract No. 14-20-0450-5743) containing 40,000 acres. These leases allowed extraction of 400 million tons of coal. The three leases were assigned to and operated by Peabody Coal Company in 1968 and, in turn, were reassigned to PWCC (collectively referred to as PWCC), in 1994. In 1987, these leases were amended to add an additional 270 million tons of coal. The 64,858-acre leased area provides for maximum coal production of 670 million tons of coal.

1.4 Prior Relevant National Environmental Policy Act Compliance

1.4.1 Navajo Generating Station and Related Facilities

Construction of NGS was initiated prior to passage of NEPA in 1969, and before the CEQ issued its "Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act" on December 31, 1970. Guidelines for federal agencies issued pursuant to NEPA by the CEQ on April 23, 1971, established NEPA compliance requirements for existing programs and projects already underway, "where it is not practicable to reassess the basic course of action…." (CEQ 1971). Consistent with these requirements, Reclamation prepared an EIS on the initial NGS Project to assess further additional major actions to minimize adverse environmental consequences, and to take into account the "environmental consequences of actions not fully evaluated at the outset of the project or program…." (Reclamation 1972b).

The 1972 NGS Project EIS summarized pre-NEPA federal actions undertaken prior to January 1, 1970. These included the following: the Secretary of the Interior's approval of the 1969 Lease between the NGS Co-tenants and the Navajo Nation; the Secretary of the Interior's grant of ROW and easements to the NGS Co-tenants; the Secretary of the Interior's execution of a contract between the U.S. and SRP for NGS water service from Lake Powell; execution of the Participation Agreement among the NGS Co-tenants and the U.S., through which the parties agreed to proceed with construction and operation of the NGS Project; and execution of interim sales contracts between the U.S. and each of the NGS Co-tenants, providing for the sale of the U.S.' share of NGS power and energy to the Co-tenants prior to CAP operation.

The 1972 NGS Project EIS also evaluated major federal actions remaining to be implemented (Reclamation 1972b). The 1972 EIS described and assessed the environmental consequences of actions planned but not yet initiated at the time the EIS was prepared. The planned actions included the construction and operation of the following features of the project:

- Navajo Generating Station;
- BM&LP Railroad;
- Black Mesa Coal Mining Operation (which included both the former Black Mesa Mine and the Kayenta Mine);
- WTS; and
- STS.

For the WTS and STS, the 1972 EIS summarized two environmental statements that had been prepared to document the evaluation and selection of the route for each system. The environmental statement prepared by the U.S. Department of Agriculture's Forest Service, regarding the proposed STS, initially considered six alternate routes. The environmental statement prepared by the Bureau of Land Management (BLM) regarding the WTS, initially considered four routes.

Reclamation prepared another EIS in 1972 covering the construction of the CAP system, consisting of the following: one concrete and three earth-fill dams; four aqueducts, including tunnels and siphons; one major and several smaller pumping plants; and transmission facilities to provide power for the pumping plants (Reclamation 1972a). There have been additional subsequent NEPA documents covering actions related to the CAP, both for construction and operation of facilities, and issuance of contracts for allocations of CAP water.

1.4.2 Navajo Generating Station Water Intake Structure Project

The water intake structures deliver Colorado River water from Lake Powell for use in operations at the NGS. Due to drought conditions beginning in 2000, the lake elevation had dropped to 3,557 feet above mean sea level by 2004, which was only 70 feet higher than the minimum water elevation necessary for the NGS water intake pumps to remain operational. Deeper intake structures were needed to ensure that cooling water would be available for the continued operation of the NGS if drought conditions persisted and lake levels continued to fall. Construction of the new intake structures required a new easement within the boundary of the Glen Canyon National Recreation Area; therefore, National Park Service was the lead federal agency for complying with NEPA for this action. In March 2005, the National Park Service prepared an environmental assessment covering the construction and operation of new, deeper, water intake structures and subsequently issued a Finding of No Significant Impact (National Park Service 2005). The new intake structures were completed in 2009, and are approximately 120 feet lower than the original structures.

1.4.3 Navajo Generating Station Water Service Contract

A contract for water service from Lake Powell for NGS, Reclamation Contract No. 14-06-300-5033, dated January 17, 1969, was executed between the U.S., acting through the Secretary of the Interior and represented by Reclamation (Upper Colorado Regional Office) and SRP, as operator of the NGS. It provided that SRP could divert up to 40,000 acre-feet per year of Colorado River water from Lake

Powell, and consumptively use up to 34,100 acre-feet per year, for the operation of the NGS. The Navajo Tribal Council enacted two resolutions approving the allocation of 34,100 acre-feet per year from Arizona's 50,000 acre-feet per year share of the Upper Colorado River Basin, Resolution CD 108-68, dated December 11, 1968, and Resolution CJW-69, dated June 3, 1969. The 1969 Water Service Contract (Contract) had an initial 40-year term with a right to renew the Contract for 20 additional years under the same terms except for renegotiation of the water charge. This Contract was renewed on July 16, 2012. The Contract will expire on July 6, 2032 (for additional information see **Appendix 1A**).

1.4.4 Black Mesa-Kayenta Mine

As a result of promulgation of the Indian Lands Program under the SMCRA (30 CFR Subchapter E) in 1984, OSMRE prepared an EIS for the "Proposed Permit Application, Black Mesa-Kayenta Mine, Navajo and Hopi Indian Reservations, Arizona" submitted by PWCC in 1985 under the permanent regulatory program.

OSMRE's final Mine EIS was issued in June 1990, and the Secretary of the Interior approved the renegotiated leases with the Hopi Tribe and Navajo Nation (OSMRE 1990). OSMRE issued a permanent program permit, AZ-0001C, for the Kayenta mining operation in 1990 and has subsequently renewed the permit four times.[9] The decision to permanently permit the Black Mesa mining operations was administratively delayed at the direction of the Secretary of the Interior, pending resolution of concerns expressed by the Hopi Tribe and the Navajo Nation regarding use of Navajo Aquifer (N-Aquifer) water for coal-slurry purposes related to the Mohave Generating Station. Black Mesa mining operations continued pursuant to the initial regulatory program (Holt 2010). The use of former Black Mesa support facilities at Kayenta Mine, discussed further in Section 1.7.2.2, continues to be subject to the initial regulatory program.

In February 2004, PWCC submitted a life-of-mine permit revision application proposing several revisions to improve and/or enhance the efficiency and cost-effectiveness of the Kayenta permit and Life-of-Mine Plan and to include Black Mesa mining operations in the permanent permit. OSMRE issued a Draft EIS on the Black Mesa Project in November 2006. After the shut-down of the Mohave Generating Station in December 2005, PWCC amended the application to update information and omit proposed permit revisions related to the Black Mesa mining operations supplying coal to the Mohave Generating Station. A final Black Mesa Project EIS was issued in November 2008 (OSMRE 2008). Included in the preferred alternative was a proposal to incorporate the former Black Mesa Mine shared facilities and remaining Black Mesa coal-resource areas into the permanent permit boundary. A Record of Decision was issued in December 2008. In January 2010, a U.S. Department of the Interior administrative law judge responsible for the administrative review of OSMRE's approval of PWCC's permit revision application ruled that the Final EIS did not satisfy NEPA and vacated OSMRE's Record of Decision (Holt 2010). In accordance with the vacated decision, OSMRE reversed the revisions to the permit, and the 2004 application for revision was abandoned.

OSMRE prepared an environmental assessment (OSMRE 2011) in response to PWCC's 5-year permit renewal application.[10] The application addressed continuation of ongoing Kayenta Mine surface coal mining and reclamation activities in coal resource areas N-9, J-19, and J-21 for the period July 2010 through July 2015. OSMRE issued a Finding of No Significant Impact and issued PWCC's renewed Permit AZ-0001E in January 2012.

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[9] When the permit is renewed an alphabetic designation is added to the permit to signify the current permit term. The current permit is AZ-0001E; when the 2015 renewal application is approved the permit will be designated AZ-0001F.

[10] SMCRA regulations grant a right of successive renewal within the approved boundaries of an existing mining permit so long as certain conditions are met. Title 30 CFR Part 773.19(d) and Title 30 CFR Part 774.15(a); Title 30 USC Section 1256(d)(1).

On February 26, 2015, PWCC submitted to OSMRE an application to renew Permit AZ-0001E, which would authorize continuation of ongoing Kayenta Mine surface coal mining and reclamation activities in coal resource areas N-9, J-19, and J-21 for the 5-year period July 2015 through July 2020. Agency action on the current permit renewal application is on administrative hold pending completion of NEPA reviews. For purposes of NEPA, the renewal application is independent of the project approvals for the Proposed Action in this EIS because the 5-year renewal application covers the period of 2015 through 2019 which is prior to the Proposed Action, and the renewal would occur with or without the Proposed Action.

1.5 Background for the Federal Agencies' Purpose and Need

Subsequent to the Navajo Nation Council approval of Resolution CJY-40-13 on July 17, 2013, which recommended and approved Lease Amendment No. 1 to be signed by the Navajo Nation President, SRP, as the NGS operating agent, sent a letter to the Secretary of the Interior on July 20, 2012, requesting that the U.S. Department of the Interior initiate compliance under NEPA, the ESA, and other applicable federal environmental laws with respect to the federal actions necessary to enable operation of NGS and its associated facilities to continue beyond December 22, 2019 (SRP 2012).

As provided in the "Navajo Project Co-Tenancy Agreement" (for additional information, see **Appendix 1A**) among the NGS Participants, SRP must obtain the prior written consent of the U.S. (acting through Reclamation) for actions that would provide for the U.S.' continued participation in NGS after 2019. Reclamation's actions, therefore, include providing its consent to the Lease Amendment No. 1 (or a lease agreement among the Navajo Nation and the continuing Co-tenants of NGS only under substantively the same terms as the 1969 Lease and proposed Lease Amendment No. 1), the 323 Grants, an extended coal supply agreement, and the extension of any other arrangements needed for continuation of operations at NGS and the Kayenta Mine through 2044, and funding for these actions. Reclamation's actions also include the negotiation of the water service contract renewal through 2044, plus decommissioning, and issuance of a ROW for a portion of the WTS that crosses Reclamation land in Nevada.

Because NGS and much of its associated facilities, including segments of the WTS and STS, are located on Navajo Nation Tribal Trust Lands, the BIA has actions associated with the project, namely, the approval of the proposed NGS Lease Amendment No. 1 (or a lease agreement among the Navajo Nation and the continuing co-tenants of NGS only under substantively the same terms as the 1969 NGS Lease and proposed Lease Amendment No. 1) and issuance of new or amended 323 Grants, described in Section 1.3 and **Appendix 1A**. The lease of lands on the Navajo Reservation is provided for by 25 USC Section 415(a), with approval of the Secretary of the Interior, for "…business purposes, including the development or utilization of natural resources in connection with operations under such leases," for up to 99 years. In accordance with 25 USC Section 323 and 25 CFR Part 169, issuance of new or amended grants is sought through application to the BIA.

PWCC holds an active SMCRA Permit (PWCC 2012 et seq.) authorizing it to mine within the Kayenta Mine permit area. Sufficient coal reserves are authorized under the existing permit to continue mining through 2026 at current production rates. On March 5, 2014, the OSMRE deemed PWCC's significant permit revision application for the Proposed Action to be administratively complete (OSMRE 2014). PWCC is seeking to revise its SMCRA Permit and Life-of-Mine Plan for the proposed KMC to adjust and identify the timing and sequence of mining operations in certain coal resource areas through 2044 (**Figures 1-4** and **1-5**), and to relocate portions of the existing Navajo Route 41 (PWCC 2012 et seq.). Additionally, PWCC is proposing to incorporate the adjacent 18,857-acre former Black Mesa Mine area into the existing Kayenta Mine AZ- 0001E permit area, which matches the mining lease boundary of 14-20-0450-5743 and 14-20-0603-9910. Facilities on the Black Mesa Mine currently being used to support the Kayenta Mine operations would be permitted as permanent program lands and all other lands would remain under pre-law or initial program land jurisdiction (**Figures 1-4** and **1-5**); however, the proposed expansion of the boundary of

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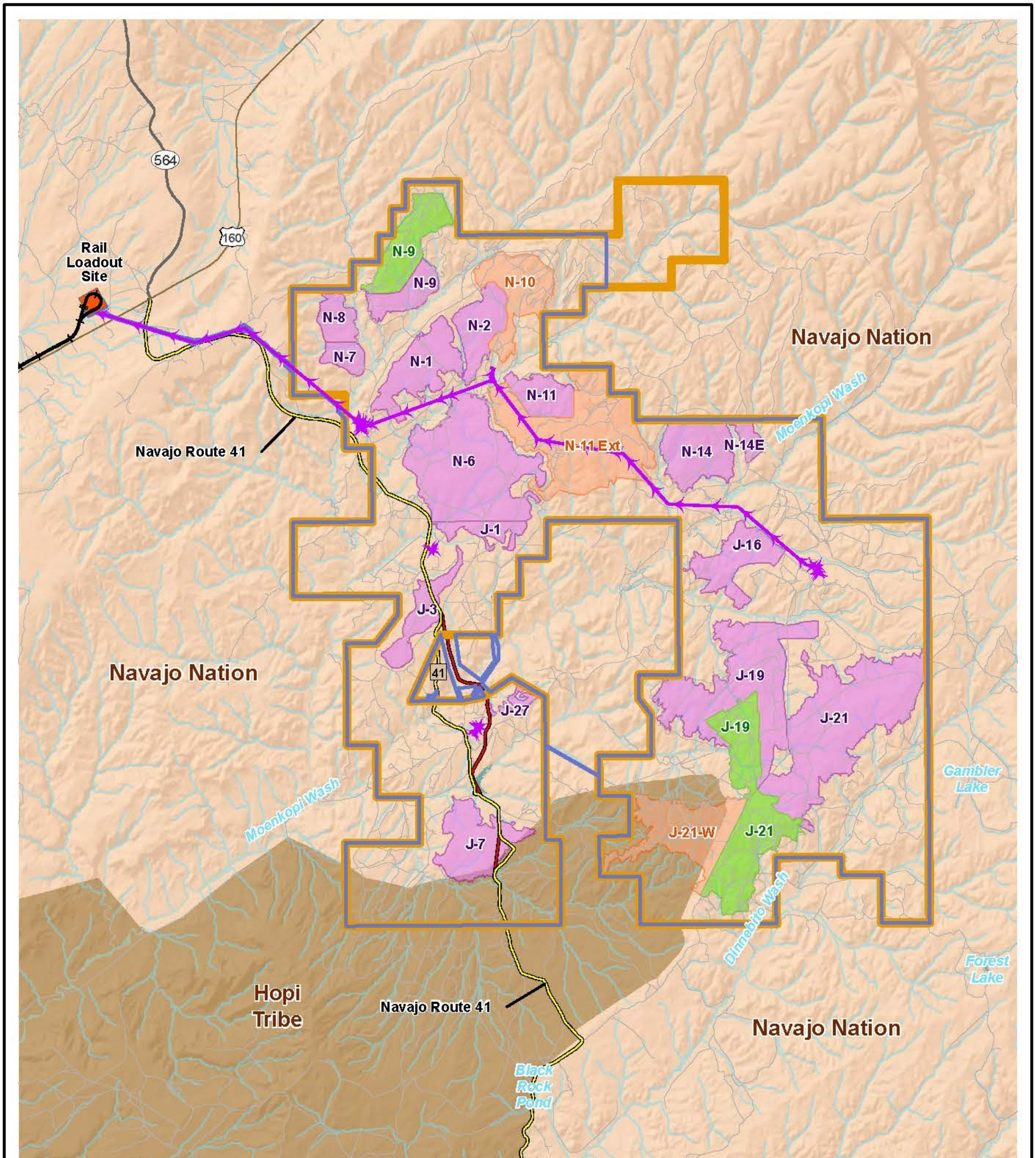

Coal Resource Area Status
- Active
- Mined Out
- Life of Mine Plan
- Conveyor Line
- Rail Loadout Site
- Proposed KMC
- Coal Lease Boundary
- Railroad
- U.S. Highway
- State Highway
- Navajo Route 41
- Proposed Navajo Route 41
- Other Road

Water Features
- River/Creek/Wash

Land Status
- Navajo Nation
- Hopi Tribe

0 1 2 3 Miles
0 1 2 3 Kilometers
1:175,000
N

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 1-5
Proposed KMC Coal Resource Areas

7/20/2016

the existing Kayenta Mine AZ-0001E permit area would not authorize any future mining anywhere in the former Black Mesa Mine area. Incorporation of these mining support facilities and the lands previously used for the former Black Mesa mining operations into the existing Kayenta Mine AZ-0001E permit area, if approved, would create the proposed KMC. The coal slurry pipeline, and associated Black Mesa Pipeline Company facilities that previously connected the former Black Mesa Mine with the decommissioned Mohave Generating Station are not PWCC facilities and are not part of the proposed NGS-KMC Project.

In addition to the actions to be taken by BIA and OSMRE, other federal agencies must act on applications to re-issue expiring ROWs and easements for portions of the WTS and STS located on federal land outside the Navajo Reservation, and provide various approvals where applicable. See **Table 1-1** for a complete list of these actions and actions by other entities associated with the project.

Table 1-1 Preliminary List of Federal Actions for the NGS-KMC Project

Entity and Role in EIS	Approval Action – NGS and Associated Facilities, WTS, and STS	Approval Action – Proposed KMC
Federal Entities		
Reclamation Role: Lead federal agency for purposes of complying with the National Environmental Policy Act (NEPA), Section 7 of the Endangered Species Act (ESA), and Section 106 of the National Historic Preservation Act, Ensure adequate coordination with the key cooperating agencies, other cooperating agencies, and affected tribes as appropriate. Ensure EIS complies with the Council on Environmental Quality, U.S. Department of the Interior, and Reclamation NEPA requirements; review and approve project mitigation; ensure all information is adequate to issue a Record of Decision based on the Final EIS analysis. Conduct Government-to-Government consultations with affected tribes.	Approve or consent to contracts and other arrangements to extend the NGS Project operations through 2044, including but not limited to: • Amendment No. 1 to the Indenture of Lease between Navajo Nation and NGS Participants (or a leasing agreement with the Navajo Nation having similar terms as the 1969 Lease and Lease Amendment No. 1); • Land grants, easements, and ROWs; • Revisions to or new Co-Tenancy Agreement and other Navajo Project Agreements among the NGS Participants; and • Extension of the Coal Supply Agreement. Develop and approve terms of a renewal contract for water service from Lake Powell for operations through 2044 pursuant to Article 2 of the January 17, 1969, Water Service Contract; 1902 Reclamation Act (32 Statute 388) as amended; and 1956 Colorado River Storage Project Act Boulder Canyon (70 Statute 105), as amended. Issue a new license for the railroad crossing under the Glen Canyon Shiprock 230-kilovolt transmission line, Contract No. 14-06-400-5882 pursuant to the 1902 Reclamation Act (32 Statute 388), as amended. Issue new easement for a portion of the WTS pursuant to the 1902 Reclamation Act (32 Statute 388), as amended. Approve and provide funding in proportion	Approve coal supply agreement between PWCC and NGS Co-tenants.

Table 1-1 Preliminary List of Federal Actions for the NGS-KMC Project

Entity and Role in EIS	Approval Action – NGS and Associated Facilities, WTS, and STS	Approval Action – Proposed KMC
	to its Participant share in NGS of the actions required for the operation of NGS, WTS, and STS according to the project agreements and for eventual decommissioning.	
OSMRE – Western Region Role: Act as key cooperating agency per Memorandum of Understanding among Reclamation, OSMRE, BIA, SRP, and PWCC. Review EIS regarding compliance with OSMRE requirements; ensure all information is adequate to issue a Record of Decision based on the Final EIS analysis. Participate in government-to-government consultations.	None	Approve a permit revision for: • Changes in the proposed KMC Life-of-Mine Plan; • Relocation of a public road; and • Adjustment of a permit boundary pursuant to SMCRA to include existing support facilities (30 USC Section 1201 et seq.). Consult on potential impacts to cultural resources. Participate in ESA Section 7 consultation.
BIA – Navajo Region Role: Act as key cooperating agency per Memorandum of Understanding among Reclamation, OSMRE, BIA, SRP, and PWCC. Review EIS regarding compliance with BIA requirements; ensure all information is adequate to issue a Record of Decision based on the Final EIS analysis. Participate in government-to-government consultations.	Approve the NGS Project Lease Amendment No. 1 (or a leasing agreement with the Navajo Nation having similar terms as the 1969 Lease and Lease Amendment No. 1) pursuant to 25 USC Section 415(a) and 25 CFR Part 162. Approve renewed, amended, or new 323 Grants of ROW and easements for the NGS Project on Navajo Nation Indian Lands pursuant to 25 USC Section 323 and 25 CFR Part 169, including but not limited to: • Plant Site and associated facilities; • Railroad; • Coal Conveyor; • WTS; • STS; • Communication Sites; and • Moenkopi Switchyard. Approve actions by the Navajo Nation to take on an ownership interest in NGS pursuant to provisions contained in the Lease Amendment No.1 (or a leasing agreement with the Navajo Nation having similar terms as the 1969 Lease and Lease Amendment No. 1), should the Navajo Nation choose to do so. Consult on potential impacts to cultural resources.	Approve realignment of Navajo Route 41 pursuant to 30 CFR Part 761.14(b). Renew or issue new grants of ROW and easements for the NGS-KMC Project on tribal lands.

Table 1-1 Preliminary List of Federal Actions for the NGS-KMC Project

Entity and Role in EIS	Approval Action – NGS and Associated Facilities, WTS, and STS	Approval Action – Proposed KMC
	Participate in ESA Section 7 consultation.	
BIA – Western Region Role: Act as cooperating agency per Memorandum of Understanding between Reclamation and BIA – Western Region. Participate in government-to-government consultations.	Approve or disapprove Pipe Spring communication site 323 Grant pursuant to 25 USC Section 323 and 25 CFR Part 169. Consult on potential impacts to cultural resources	
BIA Western Region – Hopi Agency Role: Review EIS regarding compliance with BIA requirements; ensure all information is adequate to issue a Record of Decision based on the Final EIS analysis.	None	Approve realignment of Navajo Route 41 pursuant to 30 CFR Part 761.14(b).
Bureau of Land Management (BLM) Role: Act as cooperating agency per Memorandum of Understanding between Reclamation and BLM.	Issue new Federal Land Policy and Management Act ROW grants for the STS and WTS across jurisdictional public lands in Arizona, Utah, and Nevada pursuant to Title V. Ensure use is administered consistent with Public Law 96-491 for segment through Moapa Reservation. Consult on potential impacts to cultural resources. Participate in ESA Section 7 consultation.	Approve changes to the proposed KMC Resource Recovery and Protection Plan (mining plan) pursuant to 25 CFR Part 216; 43 CFR Part 3480.
U.S. Army Corps of Engineers Role: Review the EIS for compliance with Clean Water Act regulations, if applicable.	None	As applicable, approve Section 404 permit modifications and a revision for the proposed KMC pursuant to the Clean Water Act 33 USC Section 1342; 33 CFR Parts 320, 323, 325.
U.S. Fish and Wildlife Service Role: Act as cooperating agency per Memorandum of Understanding between Reclamation and U.S. Fish and Wildlife Service.	As applicable, prepare and issue a Biological Opinion, pursuant to Section 7 of the ESA (16 USC Section 1531 et seq.). Ensure compliance with the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act.	As applicable, prepare and issue a Biological Opinion, pursuant to Section 7 of the ESA (16 USC Section 1531 et seq.). Ensure compliance with the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act.

Table 1-1 Preliminary List of Federal Actions for the NGS-KMC Project

Entity and Role in EIS	Approval Action – NGS and Associated Facilities, WTS, and STS	Approval Action – Proposed KMC
National Park Service Role: Act as cooperating agency per Memorandum of Understanding between Reclamation and National Park Service.	Renew or issue a new ROW permit to cover a portion of the underground water intake (tunnel) system that supplies water to NGS. The renewed or newly issued permit would replace ROW Permit No. RW GLCA-06-002, granted pursuant to 16 USC Section 79 and expiring in 2032, to cover the period until 2044. Renew a ROW for a portion of the WTS on the Glen Canyon National Recreational Area pursuant to 16 USC Section 5 and 36 CFR Part 14. Consult on potential impacts to cultural resources. Participate in ESA Section 7 consultation.	None
U.S. Environmental Protection Agency (USEPA) Role: Act as cooperating agency per letter dated May 28, 2014. Review EIS for compliance with applicable federal environmental regulations.	USEPA has delegated the Clean Air Action's Title V operating permit program under 40 CFR Part 71 to the Navajo Nation Environmental Protection Agency (NNEPA). NNEPA issued the current Part 71 permit for the Kayenta Mine, and PWCC has submitted a renewal application to NNEPA. Final approval of Clean Air Act Title V, 40 CFR Part 71, operating permit renewal currently is pending with NNEPA. Action on this permit renewal is anticipated to occur prior to 2020.	As applicable, approve National Pollution Discharge Elimination System permit modifications and a revision for the proposed KMC pursuant to the Clean Water Act (33 USC Section 1342); 40 CFR Part 124.9. If needed, approve Nationwide Stormwater Discharge Permit. USEPA has delegated the Clean Air Act's Title V operating permit program under 40 CFR Part 71 to the NNEPA. NNEPA issued the current Part 71 permit for the Kayenta Mine, and PWCC has submitted a renewal application to NNEPA.
U.S. Forest Service Role: Act as cooperating agency per Memorandum of Understanding between Reclamation and U.S. Forest Service.	Renew ROWs across the Kaibab and Prescott National Forests in Arizona originally granted pursuant to the Act of March 4, 1911 (36 Statute 1253, as amended by Public Law 307, 66 Statute 95). Consult on potential impacts to cultural resources.	None

Table 1-1 Preliminary List of Federal Actions for the NGS-KMC Project

Entity and Role in EIS	Approval Action – NGS and Associated Facilities, WTS, and STS	Approval Action – Proposed KMC
Non-federal Entities		
Navajo Nation Role: Act as cooperating agency per Memorandum of Understanding between Reclamation and the Navajo Nation. Participate in government-to-government consultations.	Review and approve the Clean Air Act Title V, 40 CFR Part 71, operating permit renewal application. The Navajo Nation will periodically (every 5 years) review and issue the permit. Government-to-government consultation with Reclamation on Section 7 of the ESA and special status species. Decide whether to execute the option to take on an ownership interest in NGS pursuant to provisions contained in the Lease Amendment No. 1. If needed, and as an alternative to Lease Amendment No. 1, approval of a new lease agreement among the Navajo Nation and the continuing NGS owners having similar terms as Lease Amendment No. 1. Consult on potential impacts to cultural resources.	Consult on potential impacts to cultural resources. Government-to-government consultation on Section 7 of the ESA and Special Status Species. Consult by performing a technical review of the Life-of-Mine application. Approve or disapprove Clean Water Act Section 401 water quality certifications, if needed. On behalf of USEPA, issue renewal of KMC's federal Title V operating permit, if needed.
Hopi Tribe Role: Review the EIS and provide technical information. Participate in government-to-government consultations.	Consult on potential impacts to cultural resources.	Consult on potential impacts to cultural resources. Government-to-government consultation on Section 7 of the ESA and Special Status Species. Consult by performing a technical review of the Life-of-Mine application. Approve or disapprove Clean Water Act Section 401 water quality certifications, if needed.
Gila River Indian Community Role: Act as cooperating agency per Memorandum of Understanding between Reclamation and Gila River Indian Community.	None	None
Pueblo of Zuni Role: Review the EIS and provide technical information. Participate in government-to-government consultations.	Consult on potential impacts to cultural resources.	Consult on potential impacts to cultural resources. Government-to-government consultation on Section 7 of the ESA and Special Status Species.

Table 1-1 Preliminary List of Federal Actions for the NGS-KMC Project

Entity and Role in EIS	Approval Action – NGS and Associated Facilities, WTS, and STS	Approval Action – Proposed KMC
Central Arizona Water Conservation District Role: Act as cooperating agency per Memorandum of Understanding between Reclamation and the Central Arizona Water Conservation District.	None	None
Arizona Game and Fish Department Role: Act as cooperating agency per Memorandum of Understanding between Reclamation and the Arizona Game and Fish Department.	None	None

1.5.1 Federal Agencies' Purpose and Need

In the initial stages of this EIS, the Deputy Secretary of the Interior indicated Reclamation would be the lead federal agency for the environmental compliance effort, including preparation of this EIS for U.S. Department of the Interior (U.S. Department of the Interior 2012). Due to the substantial jurisdictional responsibilities of both OSMRE's Western Region and BIA's Navajo Region, these two agencies have been defined as key cooperating agencies. The agencies have worked very closely with Reclamation staff in the preparation of the EIS and on associated environmental regulatory requirements.

As an NGS Participant, Reclamation needs to respond to the impending expiration of the initial term of the 1969 Lease, grants of ROW and easements, and other agreements needed for the continued operation of NGS. **Table 1-1** lists a summary of arrangements for which Reclamation's consent or approval is required; **Appendix 1A** provides a more detailed description of these arrangements. Reclamation's purpose for the Proposed Action is to secure, after 2019, a continuously available and reliable source of power and energy to operate the CAP pumps, which would be competitively priced with NGS and could be sold as surplus power to generate revenues for deposit to the Development Fund, and to satisfy the purposes of the Arizona Water Settlements Act.[11] This purpose and need statement was revised from the statement in the Notice of Intent published in the Federal Register on

[11] Development Fund revenues are used to assist in repayment of CAP construction costs, and for the payment of fixed operation, maintenance, and replacement charges associated with the delivery of CAP water to Arizona Native American tribes and other statutory purposes.

May 16, 2014 (Federal Register, Volume 79, No. 95) announcing Reclamation's intent to prepare an EIS for the NGS-KMC Project. The refinement to include the need for a source of power and energy that would be competitively priced with NGS, as part of the purpose and need, was made as a result of comments received during the scoping process.

OSMRE is responsible for carrying out the requirements of SMCRA in cooperation with states and tribes. As the regulatory authority on Indian Lands, OSMRE (Western Region) is responsible for ensuring that the operation of the proposed KMC permit area would be in accordance with all SMCRA requirements, including all applicable environmental performance and reclamation standards. Accordingly, OSMRE needs to respond to PWCC's SMCRA Kayenta Mine permit revision application and proposed Life-of-Mine Plan and determine whether to approve, approve with special conditions, or disapprove the application, in accordance with the requirements of SMCRA. OSMRE's purpose for the Proposed Action is to implement the environmental protections, reclamation standards, and other permitting requirements under SMCRA, while balancing the U.S.' need for continued domestic coal production with protection of the environment (see 30 USC Section 1202).

BIA must decide, consistent with the requirements of 25 USC Part 415(a) and 25 CFR Part 169, and subject to the consent of the Navajo Nation, whether or not to approve: 1) the NGS Lease Amendment No. 1 or a lease agreement among the Navajo Nation and the continuing NGS Co-tenants only under substantively the same terms as the 1969 Lease and proposed Lease Amendment No. 1; and 2) other grants of ROW issuances or renewal(s), which would allow for the continued operation of the NGS and its associated facilities (described in Section 1.2.1 and **Appendix 1A**) on Navajo Tribal Trust Land through December 22, 2044. BIA also must approve the proposed relocation of portions of Navajo Route 41 within the proposed KMC permit area on Navajo and Hopi surface lands.

The purpose of the BLM action is to respond to the Proponent's request for ROW grants across jurisdictional public lands in Arizona, Utah and Nevada. The grants would be for operation, maintenance, and removal (as applicable) of the existing WTS and STS, existing critical access roads, and communication sites. The ROW grants would be issued pursuant to the Federal Land Policy and Management Act (43 USC Section 1761) as amended, which establishes the BLM's multiple-use mandate to serve present and future generations. Consequently, the need for the BLM action is established by the BLM's responsibility under the Federal Land Policy and Management Act to respond to the Proponent's request for ROW grants, while avoiding or minimizing adverse impacts to other resource values in accordance with BLM's land-use plans within the affected field offices. The BLM's decision would apply to those portions of the Proposed Action that involve BLM-managed public lands and the trust resources BLM is charged with overseeing. BLM also must act on the proposed KMC Resources Recovery and Protection Plan, as part of BLM's Indian minerals trust responsibility. BLM will consider approval of changes to the proposed KMC Resource Recovery and Protection Plan (mining plan) pursuant to 25 CFR Part 216; 43 CFR Part 3480.

Other U.S. Department of the Interior agencies having actions associated with the Proposed Action include the BIA's Western Region, U.S. Fish and Wildlife Service, and National Park Service. The USEPA, U.S. Army Corps of Engineers, and the U.S. Forest Service also have actions associated with the Proposed Action. **Table 1-1** lists all the federal agencies having an action to take and the specific action(s). These federal agencies were invited to become cooperating agencies in the preparation of this EIS.

Each of the federal decisions at issue must be consistent with federal Indian policies including, but not limited to, a preference for tribal self-determination and promoting tribal economic development for all tribes affected by these federal decisions. In addition, the federal government has a trust responsibility to protect and maintain rights reserved by or granted to Indian tribes and individuals by treaties, statutes, and executive orders.

At the end of this NEPA process, the Secretary of the Interior or designee will approve a Record of Decision establishing how the Department will proceed. Entities within the Department will take appropriate steps to implement this decision.

1.6 Non-federal Entities

1.6.1 Non-federal Agency Actions

Tribal, non-federal, state, and local government agencies with jurisdiction by law, or special expertise with respect to a potential environmental impact associated with the Proposed Action, were invited to become cooperating agencies (**Table 1-1**; CEQ 2002). The Hopi Tribe, Navajo Nation, and 10 central Arizona tribes with CAP water allocations (Ak Chin Indian Community, Fort McDowell Yavapai Nation, Gila River Indian Community, Pascua Yaqui Tribe, Salt River Pima-Maricopa Indian Community, San Carlos Apache Tribe, Tohono O'odham Nation, Tonto Apache Tribe, White Mountain Apache Tribe, and Yavapai-Apache Nation), were invited to become cooperating agencies. The Navajo Nation and Gila River Indian Community have become cooperating agencies in the preparation of this EIS. The Central Arizona Water Conservation District (operator of the CAP), and the Arizona Game and Fish Department also are cooperating agencies in the preparation of this EIS.

1.6.2 Non-federal Project Proponents' Interests, Goals, and Objectives

Certain non-federal NGS Participants seek to continue operation of the NGS beyond the current lease agreement termination date of December 22, 2019 through December 22, 2044. The NGS provides continuous, long-term, and cost-effective baseload power to its owners' customers in the southwestern U.S. using coal, a reliable and readily available fuel source from the Kayenta Mine. PWCC desires to continue providing an uninterrupted coal supply to NGS in order for NGS to continue power plant operations through December 22, 2044.

1.7 Historical Operations

The historical (pre-2020) operations of the NGS, the Kayenta Mine, and the transmission system and communication sites are briefly described in this section to provide sufficient understanding of how the facilities have been operated and will continue to operate through 2019, how operation of the facilities would change under the Proposed Action, and how operations would be different under any of the action alternatives described in Chapter 2.0. A more detailed description of these historical operations is provided in **Appendices 1B** and **1D**.

1.7.1 Navajo Generating Station and Associated Facilities

With the exception of a small portion of the Colorado River water intake structure (**Figure 1-3**), which is located on an easement from the National Park Service, the remainder of the NGS plant and its associated facilities Is located on approximately 3,485 acres of Navajo Tribal Trust Lands located in the northwestern portion of the Navajo Reservation near Page, Arizona. These lands are subject to the Lease and ROWs between the NGS Co-tenants and the Navajo Nation. An ash disposal site for coal combustion residual materials is located east of the NGS plant site. The BM&LP Railroad, with a total track length of approximately 80 miles with the turn-around at each end, delivers coal from Kayenta Mine's loadout silos to NGS (**Figure 1-1**). Total acreage of the landfills and other major components of support operations are provided in **Table 1-2**, and more detailed descriptions are in Section 1.7.1.7. A 323 Grant of ROW for an additional estimated 66 acres encompassing an overland conveyor within the proposed KMC, that was originally issued to SRP, has been transferred over to PWCC, because PWCC has control over its use and operation; the overland conveyor acreage is not included in **Table 1-2**.

Table 1-2 Acreage of Support Operations at NGS

Facility or Operation	Total Acreage
NGS plant site	1,021
Ash disposal site (landfill)	765
Road between plant site and ash disposal site	30
Lake pump station	5
Road between pump station and N22b	3
Pipeline, powerline, and road between lake and plant site	40
Coal loadout silo	100
Railroad corridor row	1,520
230-kV tie line	1
Total	**3,485**

Source: Navajo Project Operation and Maintenance Plan, Final, April 22, 2016. Numbers rounded for presentation.

Electrical power generated at NGS is transmitted to customers and the regional power grid through two existing transmission systems, the WTS and STS (also see **Figure 1-1**) via 500-kV transmission lines. The transmission systems' 19 communication sites are located on a mix of tribal, federal, state, municipal, and private lands.

NGS operations through 2019 are described according to the sequential steps required to convert the coal fuel to electrical energy for delivery to the regional transmission grid (**Figure 1-6**). Controls implemented to reduce pollutant emissions to the environment (air, soil, surface water, and groundwater) are summarized in this section, and described in greater detail in Chapter 3.0 under each applicable resource, and in **Appendix 1B**.

1.7.1.1 Coal Storage and Handling

The BM&LP Railroad delivers low sulfur bituminous coal from the Kayenta Mine to the NGS. Coal delivery, storage, and dust controls are described in **Appendix 1B**.

1.7.1.2 Power Generation

Three pulverized coal-fired steam electric generating units provide a combined net generating capacity of 2,250 MW. Each unit powers a steam turbine and includes a condenser, cooling tower, and cooling water handling operations as depicted in **Figure 1-6**.

Coal transferred from the coal hopper is treated with a calcium bromide agent (used to control mercury emissions), then is pulverized to the required specifications and fed into each boiler furnace. A flue gas treatment system is installed on each unit. Flue gas passes through the generating unit electrostatic precipitator and sulfur dioxide (SO_2) scrubber before exiting the 775-foot-high steel-lined concrete stack.

Boiler steam feeds the three NGS electric power generation turbines, each of which yields a gross output of up to 810 MW. Steam discharged from the turbines circulates over cooling tubes of the condenser where it is cooled for recirculation through the boiler units. Additional (make-up) water is added as necessary to maintain system operation. The heat from the circulating water is removed by evaporation in six cooling towers (two for each generating unit).

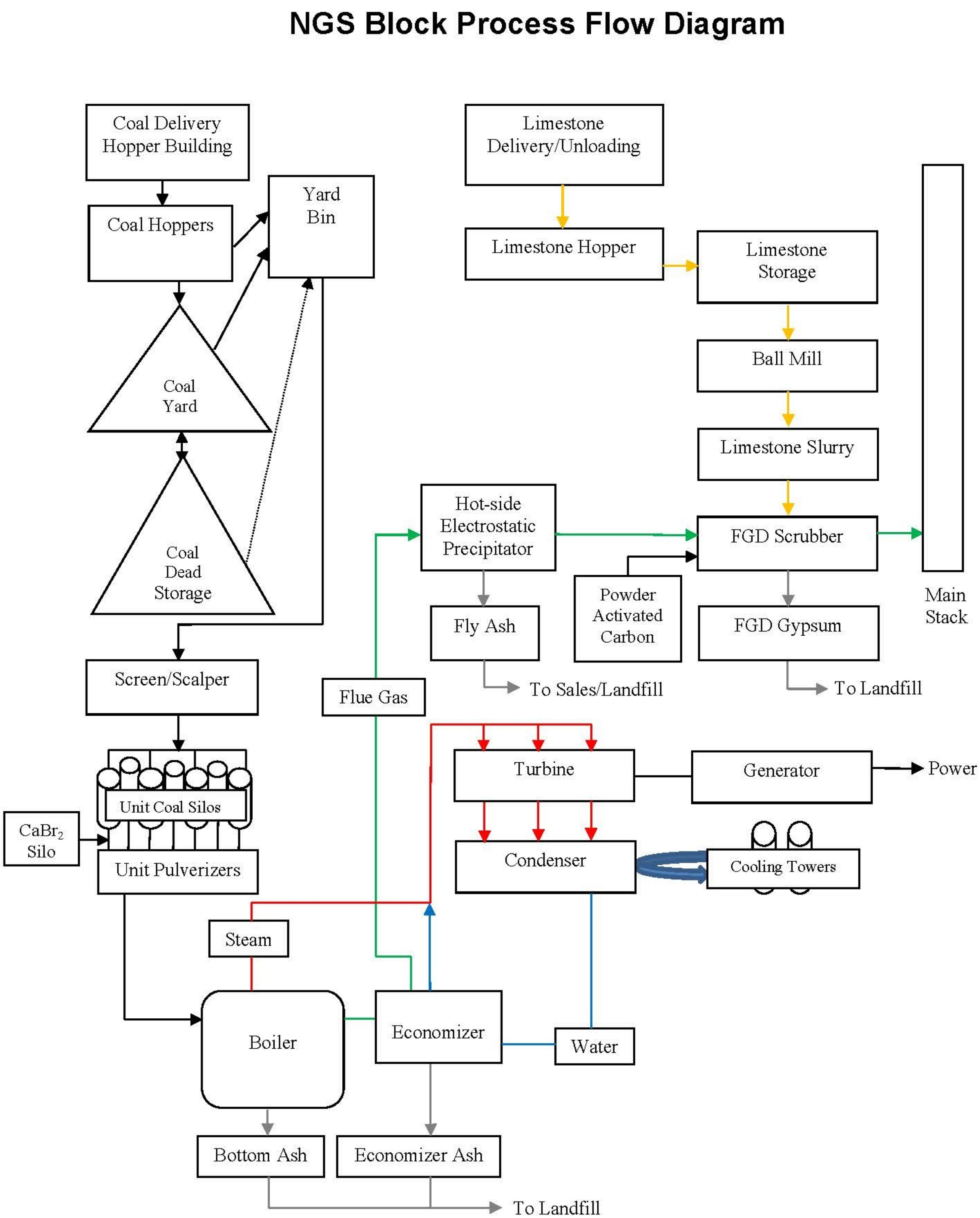

Figure 1-6 NGS Process Flow Diagram

The NGS was designed to function as a baseload plant, meaning that it was designed to operate most efficiently at near maximum output and as continuously as possible given maintenance requirements. Gross NGS annual energy output from 2009 to 2012 ranged from about 17.4 to 18.2 million megawatt-hours, with net annual output ranging from 15.8 to 16.9 million megawatt-hours. Those output levels represent a capacity factor of approximately 88 percent of design capacity. In 2014, total power production was 19,044,248 megawatt-hours with a net generation of 17,226,393 megawatt-hours, the difference of 1,817,855 megawatt-hours representing the load needed for internal plant operations. Routine operations, maintenance, repair, and other improvements are described in **Appendix 1B**.

1.7.1.3 Air Pollution Control Systems

1.7.1.3.1 Criteria and Hazardous Air Pollutants

Several air pollution control processes and systems are used to reduce emissions of mercury and hazardous air pollutants, nitrogen oxide (NO_X), particulate matter, and SO_2 from combustion flue gases. In sequence, the following activities and systems are utilized and operated to provide air emissions control.

- An electric railroad was installed to reduce emissions that would have otherwise occurred if the less expensive diesel locomotives were used.
- Fugitive dust is reduced by using baghouses at several coal and ash transfer locations inside the plant.
- Mercury emissions are reduced by mixing calcium bromide with the coal, prior to firing in the boilers. Calcium bromide is added to comply with the Mercury and Air Toxics Standards promulgated under 40 CFR 63 Subpart UUUUU.
- NO_X emissions are reduced in the boiler combustion process by low-NO_X burners that were installed on all three units, along with design modifications that were made to provide supplemental over-fire air systems, resulting in a reduction of approximately 40 percent of total NO_X emissions.
- Particulate matter at each unit is controlled by an electrostatic precipitator that is designed to capture 99.5 percent of fly ash. Particulate bound mercury is captured by these devices. The resulting “fly ash” is disposed of as coal combustion residual material, some of which also is sold as an additive to cement manufacturing.
- SO_2 emissions are reduced 90 percent by operation of a wet flue gas desulfurization scrubber that is downstream of the electrostatic precipitator. Limestone is delivered on-site, processed, and pulverized to make a liquid slurry that is mixed with the flue gases flowing through the scrubber. This mixing process captures SO_2 and other acid gases, including hydrogen chloride, which also is regulated as a hazardous air pollutant. The scrubbers also remove portions of mercury and particulate matter from the flue gas stream. The scrubber solids are processed and disposed of in the ash disposal landfill as coal combustion residual material.

Additional details regarding the emissions control devices for these units are provided in **Appendix 1B**.

1.7.1.4 Water Delivery, Use, and Treatment

The entire make-up water requirement for the three generating units is obtained from Lake Powell and delivered to the plant for a variety of functions at NGS including steam generation by the boilers, machinery bearing cooling, cooling towers, service water system, fire suppression system, and potable water. The lake pump station site is adjacent to the lake shore on a parcel of land leased to NGS by the Navajo Nation and includes the water intake wells and buildings that house pumps and electrical transformers. Five submersible first stage pumps lift the lake water to five second-stage booster pumps via independent pipelines, discharging the raw lake water into a discharge manifold. The manifold is connected to two 30-inch concrete cylinder supply lines that discharge at the power plant site into two

11-foot-diameter, 27-foot-high influent tanks that feed the make-up water clarifiers. The concrete cylinder pipelines for transporting the water to NGS, and the power lines from the plant's switchyard to the lake pump station for powering the pumps, are located within a 2.85-mile-long ROW. The pipelines are buried from 5 to 20 feet deep. The power lines, along with communications and control cables (fiber optic cables), are suspended from single wooden poles ranging from approximately 40 feet to 55 feet tall. Cathodic protection wells and monitors also are located within the ROW.

NGS is allocated 34,100 acre-feet per year for consumptive use, and 5,900 acre-feet per year for non-consumptive use. Over the past 15 years, annual consumptive water use has ranged from about 26,000 to 29,000 acre-feet per year. Water is treated, reused, and recirculated to the maximum extent possible to minimize withdrawals from Lake Powell. NGS is designed to be a zero liquid discharge facility, meaning that all water brought into the plant site is reclaimed, reused, and eventually evaporated such that no liquid is discharged from the plant site. The 5,900 acre-feet allocated for non-consumptive use has never been utilized.

NGS operates its own water treatment facility to remove hardness and adjust pH prior to use in the power plant systems. After treatment, the water stays in make-up reservoirs until it is distributed to various water systems that use softened water.

1.7.1.4.1 Potable Water

Water from Lake Powell is treated on-site at a water treatment plant and delivered via pipelines throughout the facility for drinking water and other potable uses. The facility is in compliance with requirements under Safe Drinking Water Act regulations.

1.7.1.4.2 Cooling Towers

The cooling towers at NGS are part of a circulating water system that provides cooling water to the main turbine condensers and bearing cooling water systems. NGS operates six cooling towers, two per unit. Each cooling tower is approximately 400 feet long and 3 stories tall (**Figure 1-7**).

Figure 1-7 One of Six Cooling Towers at Navajo Generating Station

Plant cooling water circulates repeatedly, and much of it is evaporated at the cooling towers. Evaporation results in higher solids concentrations in the cooling water system. To keep the solids concentration within acceptable limits, a cooling tower blowdown system draws off a circulating water stream which is replaced with fresh water. The circulating water containing high dissolved solids is sent to holding basins from which it is treated and recycled.

1.7.1.4.3 Wastewater Management

As noted above, NGS is designed to be a zero liquid discharge facility. Wastewater processing facilities are designed to recover and recycle cooling tower blowdown water and storm runoff from the developed area of the facility. Wastewater is processed through brine concentrators and a crystallizer, removing the solids and reclaiming water for reuse in the plant. A small amount of storm water runoff discharges offsite per a USEPA Multi-sector storm water general permit. A series of inter-connected lined wastewater holding ponds are used to store, transfer, and evaporate process water. Stormwater runoff from the ash disposal area is captured on-site and evaporated. Groundwater protection measures are used to prevent and monitor for any evidence of leakage from wastewater ponds. Sewage is processed in a step-aeration activated sludge treatment plant. The treated sewage effluent water is chlorinated and reclaimed back to water treatment influent for reuse. **Appendix 1B** provides additional details regarding wastewater treatment systems at NGS.

1.7.1.4.4 Groundwater Protection

A Groundwater Protection Plan has been implemented at NGS to ensure that water quality in the regional N-Aquifer, located approximately 900 feet below ground level, is not adversely affected by past, current, and future plant operations. The components of the plan that contribute to this effort include groundwater monitoring, formalized inspections and testing, engineering controls to avoid and minimize loss and transmission of NGS plant waters into the ground, measures to capture and reclaim water that has saturated soils, and implementation of additional Best Management Practices for protecting groundwater.

Three deep monitoring wells at the plant and ash disposal site provide monitoring of groundwater levels and water quality to ensure protection of the N-Aquifer. Recent improvements in engineering controls and monitoring have been implemented on several ponds. Additional pond liner system upgrades are scheduled in upcoming years on a prioritized basis. Installation and implementation of an extraction system for removal of shallow perched water from saturated soils beneath the main plant site began in May 2014 (see **Appendix 1B** for full description of the Groundwater Protection Plan).

1.7.1.5 Roadways and Traffic

Routine vehicle traffic occurs at NGS to provide operational support and maintenance. NGS receives numerous bulk deliveries of chemicals, diesel, and other products required for operation of the facility; types and quantities of chemicals delivered are summarized in **Table 1-3** and described in the sections that follow and **Appendix 1B**. Periodic deliveries of these materials, typically by large diesel-fueled trucks, are made throughout the year from various sources. Limestone deliveries are the most frequent and are required for operation of the SO_2 scrubber flue-gas desulfurization system used for SO_2 emission control.

Dozers, loaders, and other heavy equipment are used to manage the dead coal storage stockpile and perform other maintenance functions. NGS contractors operate vehicles and equipment, including off-road haulers, for use in dust suppression, fly ash hauling, and other operations.

1.7.1.6 Fuel and Chemical Storage and Use

NGS uses diesel fuel oil for its main boiler igniters, warm-up oil guns, and as the main fuel source for its auxiliary boilers. Gasoline and diesel for vehicle operations are dispensed from an on-site fueling station.

NGS requires a continual delivery of chemicals to maintain its operations. **Table 1-3** lists the primary material products delivered, number of deliveries per year, and the individual load size. The materials generally are delivered by heavy duty trucks from various suppliers.

Table 1-3 Historical Chemical Delivery to NGS

Product	Truck Deliveries (2014) Year	Load Size	Point of Origin
Limestone	3,664	25 ton, 37.2 ton, or 41 ton trucks	Apex, NV
Calcium Bromide	300-500	3,200 gallons	TBD
Powder Activated Carbon	TBD	TBD	TBD
Diesel	175	7,200 gallons	Holbrook, AZ: Phoenix, AZ; Las Vegas, NV; Farmington, NM; American Fork, UT
Ammonium Hydroxide	3	45,000 pounds	Salt Lake City, UT
Caustic soda	5	3,600 gallons	Buckeye, AZ
Sulfuric acid	151	3,300 gallons	Hayden, AZ
Lime	122	40 tons	Cricket Mountain, UT
Ferric sulfate	27	71,000 pounds	Salt Lake City, UT
Ferric sulfate	2	44,000 pounds	Salt Lake City, UT
Ferric sulfate	1	20,000 pounds	Salt Lake City, UT
Sodium hypochlorite	30	45,000 pounds	Henderson, NV
Hydrogen (liquefied)	11	111,000 cubic feet	Phoenix, AZ
Carbon dioxide (liquefied)	10	9.3 tons	Phoenix, AZ
Nitrogen (liquefied)	2	53,000 cubic feet	Tucson, AZ
Soda Ash	263	24 tons	Argus, CA

Note: Data is based on 2014 calendar year with the exception of calcium bromide, which is based on projected actuals. The quantity of powder activated carbon for mercury control is unknown at this time.

A site-specific Spill Prevention, Control, and Countermeasure Plan, described in **Appendix 1B**, identifies measures taken to prevent fuel oil discharges and mitigate the impact of any discharge to navigable waters of the U.S. A tank inspection program, earthen berms, and other structures are key provisions of this plan.

1.7.1.7 Landfills and Waste Management

SRP operates two landfills within the NGS lease area, one for coal combustion residual (ash) disposal, and one for asbestos disposal from dismantled facility components containing asbestos. Solid waste was previously disposed in an on-site landfill that has been inactive since 2015; all solid waste is now sent offsite to a regulated landfill. This section summarizes the facilities and operations for the two landfill facilities. The list of NGS landfills is provided in **Table 1-4** along with approximate surface areas.

Table 1-4 Summary of Landfills at NGS

Landfill	Wastes Handled	Surface Area (acres)
Ash Disposal	Coal combustion residual materials, including bottom ash, fly ash, economizer ash, and scrubber (gypsum) byproduct	765
Solid Waste (inactive as of 2015)	Office wastes, containers	13
Asbestos	Asbestos-containing materials	3

1.7.1.7.1 Coal Ash Disposal

Three different types of coal ash are created in the NGS boilers. Bottom ash is heavy ash that falls to the bottom of the boiler. Economizer ash is light ash that is carried part way through the boiler and falls out of the gas stream in the economizer section before it leaves the boiler. Fly ash is the lightest ash that leaves the boiler in the flue-gas stream, and is collected in the precipitators. Each of these ash types is handled and processed before being transported to the ash disposal site (**Figure 1-8**) or sold and recycled off site. The solid materials from the scrubber sludge (gypsum) byproducts also are disposed of at the ash disposal site. All coal combustion residual materials contain moisture before disposal; however, the ash disposal site is a dry landfill and does not use wet ponds to store ash waste. Because of the dry and warm climate residual moisture in coal ash is rapidly evaporated. **Appendix 1B** provides additional details of coal combustion residual characteristics and disposal operations.

Volumes of on-site ash disposal in 2014 were as follows:

- Fly Ash and Economizer Ash – 295,246 tons;
- Bottom Ash – 173,394 tons; and
- Scrubber byproducts – 458,048 tons.

A total of 380,739 tons of fly ash were sold off-site in 2014.

The ash disposal site is located approximately 1 mile east of NGS against the west edge of a sandstone outcrop. The ash disposal site is 765 acres, with a design capacity of 38 million cubic yards; approximately 50 percent of this design capacity remains available (see the Groundwater Protection Plan, **Appendix 1B**).

Terraced slopes within the ash disposal site contain areas of active disturbance and undisturbed areas that support native vegetation. The coal combustion residual (CCR) material is deposited in horizontal terraces against the steep vertical walls of the sandstone outcrop in individual layers or lifts not exceeding 15 vertical feet. The final top layer is covered with a 2-foot-thick layer of native soils and benched onto the adjacent natural ground; the bench areas are sloped to divert or minimize runoff. Closure of successive terraces minimizes the active portion of the ash disposal area.

The use of dry disposal in conjunction with the dry climate and geology of the region reduces the mobility and leachability (downward movement) of any of the CCR constituents. Furthermore, retention of stormwater runoff, dust control, and groundwater monitoring procedures ensure the CCR constituents are contained on site.

NGS Environmental Department personnel conduct landfill inspections at least monthly and take corrective action as needed. An NGS contractor provides a monthly summary to SRP on the amount of materials hauled off-site, materials stored on-site, and water used for dust suppression.

USEPA published its final Coal Combustion Residual Rule in the *Federal Register* on April 17, 2015. These wastes are regulated under Subtitle D of the Resource Conservation and Recovery Act as non-hazardous waste. Additional information can be found in **Appendix 1B**.

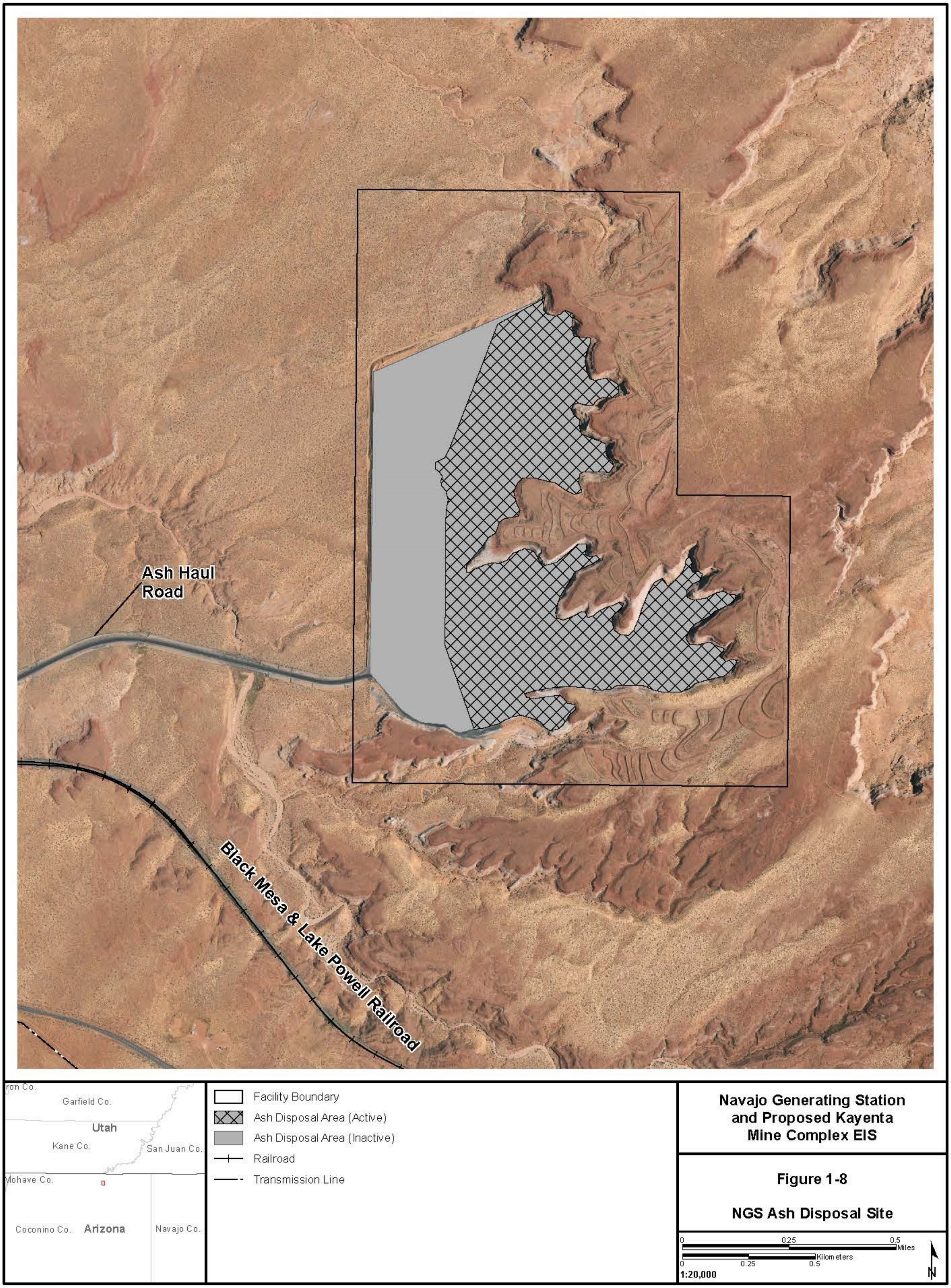

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Figure 1-8

NGS Ash Disposal Site

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1.7.1.7.2 Solid Waste Landfill

A 13-acre solid waste landfill (inactive in 2015) is located east of the railroad loop. When the landfill was active, a cover was applied to each cell in a manner that promotes runoff of water without excessive erosion. The cover was designed so surface water runoff will not leave NGS property or collect on the surface of the landfill.

A written closure plan utilizing Best Available Control Technology will be developed when final closure plans are complete.

1.7.1.7.3 Asbestos Landfill

The 3-acre asbestos landfill is located southeast of the railroad loop and accepts only asbestos waste generated at the plant site during abatement or demolition activities. It is permitted and managed as an active landfill in accordance with USEPA regulations. Restricted area signs have been installed at the gated entrance and along the perimeter fence. Operational and closure procedures for the asbestos landfill are provided in **Appendix 1B**.

1.7.1.7.4 Solid Waste Management

NGS utilizes waste minimization practices. Salvage materials include used equipment, instrumentation, and office furniture. Recycle materials include paper products, scrap metal, wood, fly ash, aluminum cans, plastic bottles, printer cartridges, electronic waste, fluorescent lights, rechargeable batteries, and tires.

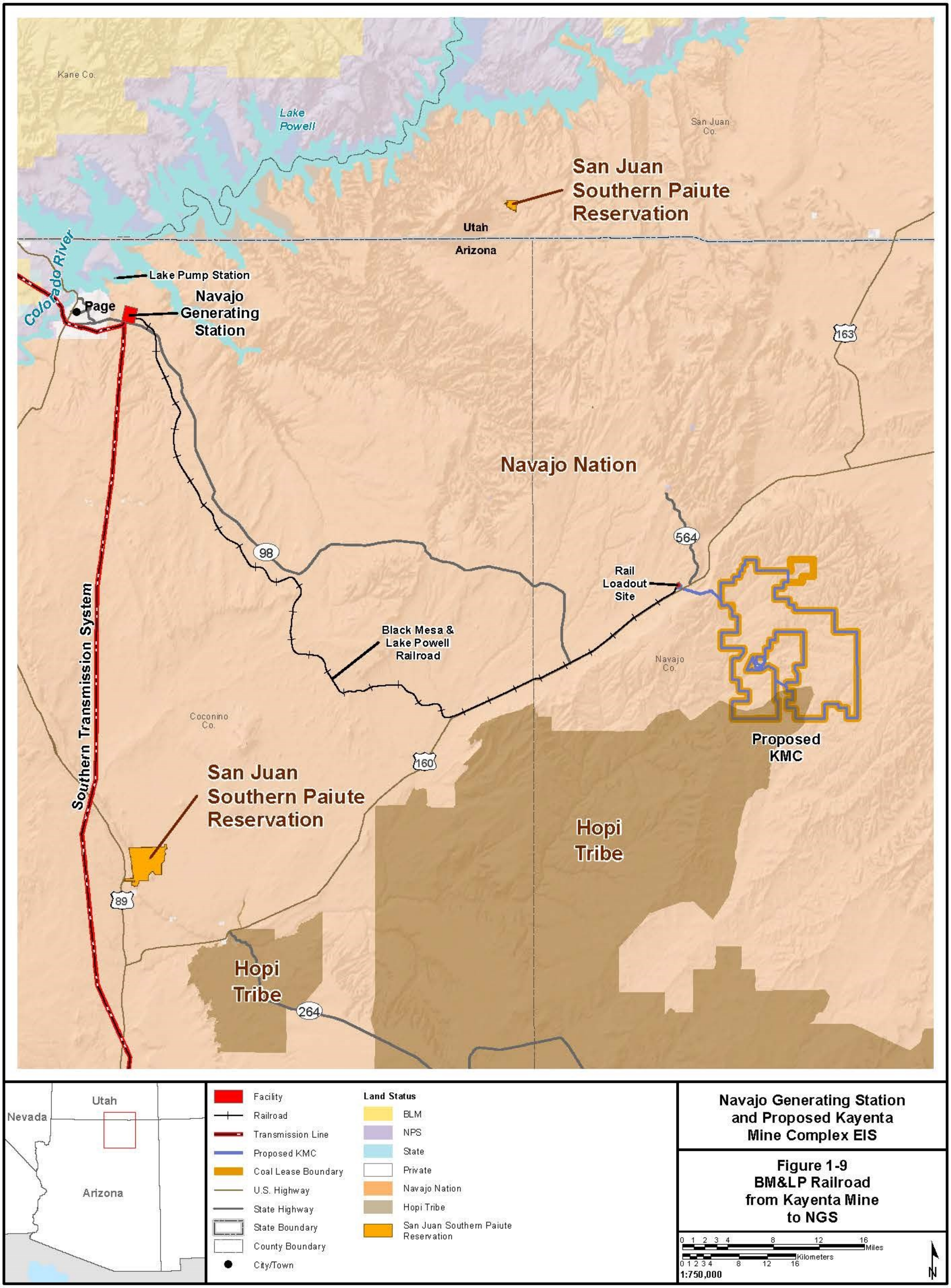
Service contracts are used to stage trash dumpsters throughout the plant site and when full to transport the waste material to off-site landfills. The amount of material sent to the NGS solid waste landfill decreased over the years, the landfill has been inactive since 2015 and deposited materials are controlled and subject to management approval.

1.7.1.7.5 Hazardous Waste Management

As a Small Quantity Generator, NGS implements a Hazardous Waste Minimization Plan using the best available and affordable waste management methods to minimize waste generation. Waste minimization includes a number of actions including eliminating and minimizing waste at the source, reclaiming, reusing material, and training. Waste minimization actions encompass a variety of techniques – technology or process modifications; reformulation or redesign of products; substitution of raw materials; and improvement in work practices (e.g., housekeeping, maintenance, and inventory control). Annual waste generation at NGS has decreased substantially from 39,000 pounds in 1991 to about 1,928 pounds in 2012.

1.7.1.8 Railroad and Coal Delivery to the Navajo Generating Station

The BM&LP Railroad is used to deliver coal from the Kayenta Mine to NGS and is not interconnected with any other rail lines. As shown in **Figure 1-9**, the track extends 78 miles northwest from the coal loading site near the Kayenta Mine on the north side of U.S. Highway 160, generally to the west then northwestward to NGS. Including the railroad loops at each end, the total length of the system is approximately 80 miles. When NGS is operating at full capacity, the train runs up to 24 hours per day, 7 days per week. Three round-trips are completed each day and approximately 8,000 tons of coal are delivered in each trip. Each 100-ton capacity railcar is filled to a level below the top edge to minimize spillage and wind exposure when the train is in motion. For most of its length, the rail is a single track. The Midway maintenance facility and a passing track/siding are located at milepost 42 near the center of the railroad line. Train operation is limited to a maximum of 50 miles per hour.



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 1-9
BM&LP Railroad from Kayenta Mine to NGS

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The BM&LP Railroad is powered by a 50-kV overhead catenary system with energy purchased from the Navajo Tribal Utility Authority under an electric service agreement between Navajo Tribal Utility Authority and SRP on behalf of the NGS Participants. NGS is responsible for operating, maintaining, and improving all facilities required for the transformation and transmission of the electric power and energy for railroad operation from the NGS switchyard to the train.

Further details of railroad operations and safety measures are provided in **Appendix 1B**.

1.7.2 Proposed Kayenta Mine Complex

PWCC has been granted three coal mining leases over 64,858 acres by the Navajo Nation and Hopi Tribe (Section 1.1). Altogether, these coal mining leases provide PWCC the right to produce up to 670 million tons of coal.[12] Historically, the lease areas were mined as two separate operations: the Kayenta Mine, which supplies coal to NGS, and the former Black Mesa Mine, which supplied coal to the Mohave Generating Station through December 2005 after which the Mohave Generating Station was closed and decommissioned. The former Black Mesa Mine encompasses approximately 18,857 acres.

The Kayenta Mine continues to operate as the sole commercial coal provider to NGS. The Kayenta Mine encompasses an area of approximately 44,073 acres. **Figure 1-9** shows the existing permit boundary for the Kayenta Mine and **Figure 1-10** shows the Initial Program administration boundary for the former Black Mesa Mine. Activities in each mine area through 2019 are summarized below with additional details contained in **Appendix 1D**. The total lease area (64,858 acres) is slightly larger than the combination of the Black Mesa Mine and Kayenta Mine Permit Areas (62,930 acres).

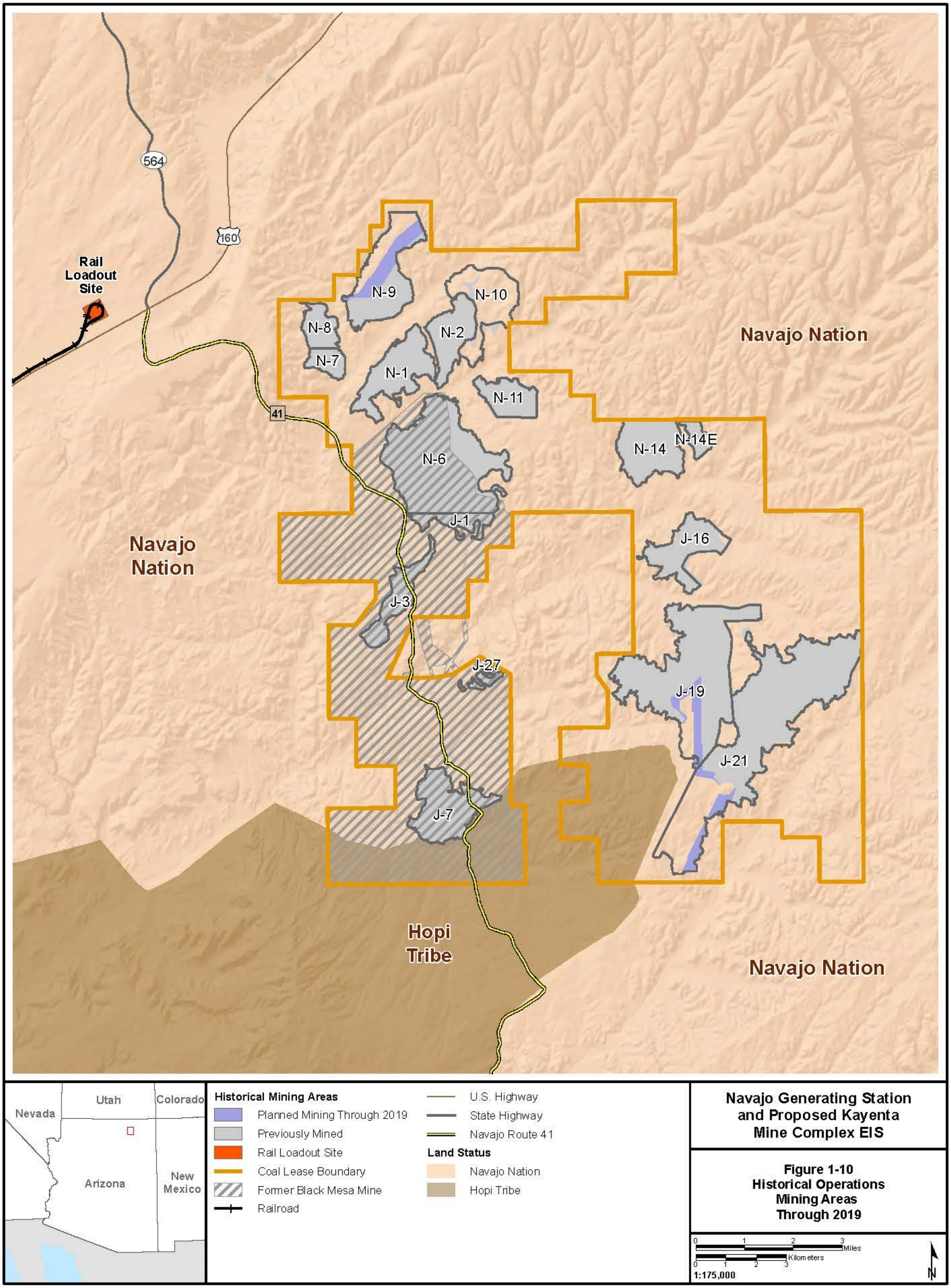
In addition to the coal mining leases, PWCC also holds ROWs totaling approximately 456 acres: approximately 164 acres for an overland conveyor and rail loadout; approximately 283 acres for a coal haulage road, buried waterline, underground telephone line, transmission line, sedimentation ponds, utilities access, and maintenance roads and water well monitoring roads; and approximately 9 acres for a powerline corridor. There also are several monitoring sites scattered within the leasehold.

1.7.2.1 Kayenta Mining and Mine Support Facilities

1.7.2.1.1 Mining Requirements

A Permanent Program Permit, No. AZ-0001C was issued to Kayenta Mine on July 6, 1990. The currently approved Life-of-Mine Plan accommodates mining through 2026 at the current production rate (PWCC 2012 et seq.). As required under SMCRA, the permit has been renewed every 5 years since 1990; the current approved renewal for operations at the Kayenta Mine is from July 6, 2010, to July 5, 2015 (Permit No. AZ-0001E). A renewal application to cover the next 5-year renewal period (July 6, 2015, to July 5, 2020) is under separate review by OSMRE (PWCC 2012 et seq.). Because the Proposed Action of this EIS would begin December 23, 2019, the EIS assumes the pending 5-year renewal is issued for operations through December 22, 2019.

[12] The coal-mining leases provide PWCC with the rights to prospect, mine, and strip leased lands to produce coal and kindred products, including other minerals that may be found, except for oil and gas. PWCC also is given the right to construct support facilities such as buildings, pipelines, tanks, plants, and other structures; make excavations, stockpiles, ditches, drains, roads, spur tracks, electric power lines, and other improvements; and to replace machinery and other equipment and fixtures and do all other things on the leased lands necessary to carry on mining operations, including rights of ingress and egress, and to develop and use water for the mining operations, including the transportation of coal mined from the leases.



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 1-10
Historical Operations Mining Areas Through 2019

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Through December 22, 2019, the Kayenta Mine would continue to produce coal in three existing approved coal resource areas (J-19, J-21, and N-9). Annual production at the Kayenta Mine through 2019 would average approximately 8 million tons from the three mine areas, as shown in **Table 1-5**.

Table 1-5 Production Volumes through 2019 (from March 27, 2015 Life-of-Mine Plan Significant Revision)

Year	Mine Area J-19 (tons mined x 1,000)	Mine Area J-21 (tons mined x 1,000)	Mine Area N-9 (tons mined x 1,000)	Total (tons mined x 1,000)
2015	3,249.5	2,256.9	2,221.2	7,727.6
2016	3,323.5	2,056.7	2,190.8	7,571.0
2017	2,810.0	2,658.7	2,396.6	7,865.3
2018	2,831.8	2,843.8	2,293.4	7,969.0
2019	3,026.2	2,810.0	2,118.5	7,954.7

Coal is surface mined through conventional strip mining methods in a series of parallel pits in each mine area. Preparation and mining activities include clearing and grubbing, topsoil removal, blasting, overburden removal, coal removal, backfilling, and reclamation.

Historical mining operations at the Kayenta Mine utilize mine support facilities located on both the Kayenta Mine and the former Black Mesa Mine. This use is authorized under SMCRA and the existing permit; use of the support facilities was evaluated as part of the most recent renewal of Permit AZ-0001E. **Table 1-6** identifies the existing mine support facilities at each location that have received approval by OSMRE and are permitted for use as part of the operations at the Kayenta Mine. **Figure 1-11** shows support facilities for the proposed KMC.

Former Black Mesa Mine facilities that will continue to be used for Kayenta Mine operations through 2019 total approximately 566 acres; their land jurisdiction will change initial program lands to permanent program lands jurisdiction. These shared facilities and the associated acreage for each type of facility are described in **Table 1-7**. All other former Black Mesa Mine lands will remain as undisturbed lands, pre-law lands, or initial program land.

PWCC's permanent permit and SMCRA regulations allow for the placement of certain temporary storage facilities without prior approval from OSMRE. These include mulch storage areas; skid mounted fuel and water tanks; small skid mounted sheds and storage bins; fire, first aid, and portable toilet stations located in active working areas; small structures on foundation less than or equal to 100 square feet in size; and portable dragline power substations or transformers and trailing cable lines. The only Kayenta Mine support facilities planned for new construction through the end of 2019 are temporary sedimentation ponds, topsoil stockpiles, and ramp roads. All other support facilities discussed are existing facilities.

Haul trucks transport the excavated coal from the Kayenta Mine pits to coal-handling areas at J-28 Facilities and N-11 Facilities, where the coal is dumped into hoppers (**Figure 1-11**). If the hoppers are full, or the crushing operations are shut down, the coal is stockpiled at the coal-handling facility. At each coal-handling facility, the coal is crushed, and screened to minus 2 inches in diameter. Coal samples are taken to evaluate coal quality to meet NGS specifications. The coal is then conveyed from facilities at J-28 and N-11 to the central sorting and blending facility at the N-8 coal-handling facility. At the N-8 coal-handling facility, the coal quality is monitored, blended if needed, or stored prior to conveyance to the storage silos at the BM&LP Railroad loadout.

Table 1-6 Permitted Mine Support Facilities

Facility	Kayenta Mine	Former Black Mesa Mine
Facilities and Buildings		
Coal-handling and storage facilities	X	–
Mine warehouse buildings	X	X
Offices	X	X
Shops	X	X
Bath houses	X	–
Employee Trailer Park	–	X
Blasting materials storage silos and cap magazines	X	–
Equipment storage areas		
Sheds constructed on permanent foundations (>100 square feet in size)	X	X
Water-Related Facilities		
Fresh water storage facilities	X	X
Sedimentation ponds	X	X
Water diversions	X	–
Waterlines	X	X
Roads	X	X
Permanent fuel storage and tank farms	X	X
Airfield and associated facilities	–	X
Powerlines	X	X
Scoria Pits	X	X
Environmental Monitoring Facilities		
Air quality and meteorological monitoring stations	X	X
Surface water and groundwater quantity and quality monitoring sites (excluding ponds)	X	X

Table 1-7 Former Black Mesa Mine Facilities in Use for Kayenta Mine through 2019

Facility Type	Approximate Acreage
Facilities and Buildings	58
Water-Related Facilities - Sedimentation Ponds, Fresh Water Storage Facilities	71
Mine water supply wells and waterline	34
Roads	164
Airfield	85
Powerlines	61
Scoria Pit	91
Environmental Monitoring	2
Total	**566**

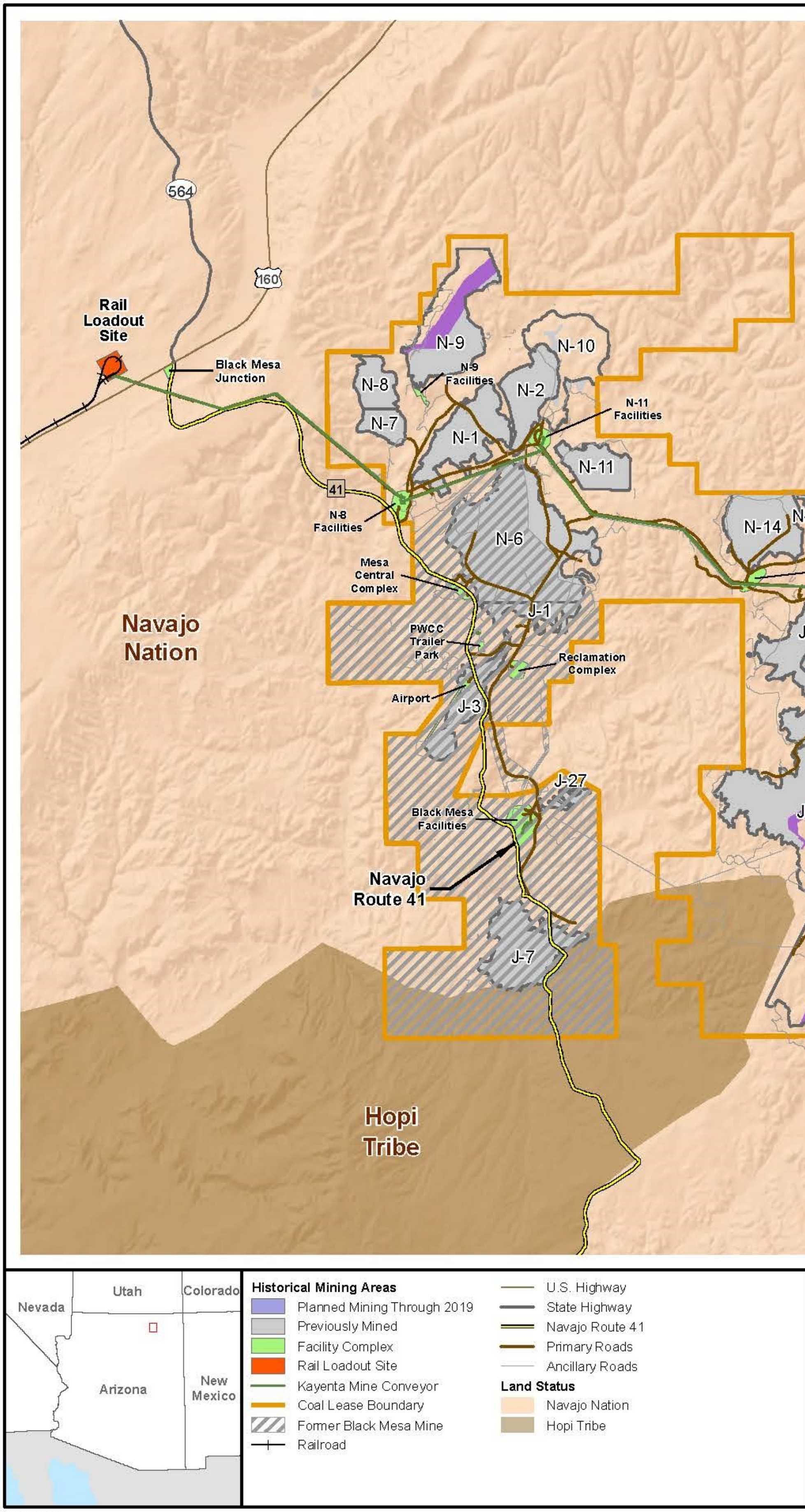

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Figure 1-11
Historical Operations Roads and Facilities

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1.7.2.1.2 Water Supply and Control Facilities

Water use and management facilities used for Kayenta Mine operations are located at both the Kayenta Mine and former Black Mesa Mine. **Table 1-8** indicates the number and locations of water use and management facilities. They are described in more detail in Section 3.7, Water Resources.

Table 1-8 Permitted Water Use and Management Facilities at the Proposed KMC

Type	Count	Total	Notes
Permanent Impoundment	23	50	Permanent impoundments
Permanent Impoundment (2015-2020)	1		
Permanent Impoundment (MSHA)	9		
Permanent Impoundment (RLRA)	6		
Permanent Impoundment (2015-2026)	—		
Internally Draining Permanent	11		
MSHA Size Structure (Temp)	2	115	Temporary impoundments
Temporary Impoundment	11		
Temporary Impoundment (2015-2020)	4		
Temporary Sediment Pond (2015-2020)	106		
Temporary Sediment Pond (2015-2026)	—		
J21W (2015-2026) (not in table)	—		
Temporary Impoundments	8	101	Reclaimed/Removed
Structure Reclaimed	81		
Structure Reclaimed (AZ-0001C)	2		
Structure Reclaimed (SAE)	9		
Structure Reclaimed (SAE) (Interim Program)	1		
Facility			
Water Diversions - Kayenta Mine	6	6	—
Water Diversions - Former Black Mesa Mine	0		
Water Quality and Quantity Monitoring Stations or Wells (excluding Ponds) - Kayenta Mine	48	69	
Water Quality and Quantity Monitoring Stations or Wells (excluding Ponds) - Former Black Mesa Mine	21		
National Pollution Discharge Elimination System Outfalls - Kayenta Mine	62	110	
National Pollution Discharge Elimination System Outfalls - Former Black Mesa Mine	48		

The Kayenta Mine obtains its water supply by pumping groundwater from three deep production wells (NAV-2, NAV-6, and NAV-8) located in the northwest part of the coal lease area. These wells were constructed to primarily withdraw water from the N-Aquifer, but wells NAV-2 and NAV-6 are open to both the N- and D-Aquifers (see Section 3.7.3 for a discussion of aquifers). Production wells NAV-6 and NAV-8 are located on the Kayenta Mine permit area. NAV-2 is located in the former Black Mesa Mine area. Four additional deep wells (NAV-3, NAV-4, NAV-7, and NAV-9) are located in the former Black

Mesa Mine area; none are actively used for production.[13] Historic annual groundwater withdrawals ranged to a high of approximately 4,500 acre-feet per year, but after 2005, they have been approximately 1,200 acre-feet per year and are not expected to change through 2019 (**Figure 1-12**). Most pumped water is used for dust control, coal preparation, and domestic (potable and sanitation) purposes.

In accordance with federal regulations, PWCC controls sediment and runoff discharges from disturbed areas using both structural and non-structural best management practices. PWCC primarily uses sedimentation ponds to prevent, to the extent possible, additional contributions of suspended solids and sediment to streamflows or runoff outside the permit area resulting from mining disturbance. All surface drainage from the mining disturbed areas is routed through a siltation structure prior to leaving the permit area. All sedimentation ponds provide adequate detention time to allow suspended solids to settle out and to ensure effluent from the ponds meets applicable tribal and federal effluent limitations. PWCC has a point-source discharge permit under the National Pollution Discharge Elimination System Program for point source discharges from sedimentation ponds. The USEPA also has granted PWCC coverage under their Multi-Sector General Permit for Stormwater Discharges Associated with Industrial Activities for any precipitation-related discharge not covered under the existing National Pollution Discharge Elimination System Permit (i.e., for those precipitation-related discharges which are not routed through a siltation structure). For additional information on National Pollution Discharge Elimination System and stormwater discharges see Section 3.7.

A cooperative permit program is used by the OSMRE, USEPA, Tribal agencies, and the BIA to review the sediment control plan and associated technical documentation in accordance with SMCRA and Clean Water Act jurisdictions. The USEPA administers the National Pollution Discharge Elimination System permit in coordination with both the Navajo Nation and Hopi Tribe, and sets effluent limitations and monitoring and reporting requirements for releases of treated effluent to receiving waters. All National Pollution Discharge Elimination System permit requirements are implemented by PWCC. There are 62 National Pollution Discharge Elimination System outfalls (permitted locations that discharge to receiving waters) for PWCC operations at the Kayenta Mine area. Another 48 National Pollution Discharge Elimination System outfalls are located in the former Black Mesa Mine area. An additional provision in the National Pollution Discharge Elimination System permit is that PWCC shall continue to implement the Seep Monitoring and Management Plan, designed to: 1) identify and characterize seeps; 2) identify seeps that may pose a threat to water quality; and 3) establish BMPs at seeps determined to pose a threat to water quality. Tribal water quality requirements are specified as general discharge standards in the National Pollution Discharge Elimination System permit, with the objective of minimizing pollutant discharges and their effects on human health, public safety or welfare, and aquatic plants and animals.

Most of the runoff and sediment control features associated with the National Pollution Discharge Elimination System permit are relatively small detention structures that are built, maintained, and then reclaimed as mining and mine reclamation activities proceed across the landscape. However, approximately 21 permanent impoundments are to remain on reclaimed surfaces at the Kayenta Mine to provide post-mining stock watering and wildlife habitat. These structures have been identified in consultation with OSMRE and tribal representatives.

[13] On April 25, 2016, PWCC notified OSMRE that NAV-7 was completely reclaimed and is no longer usable. Additionally, NAV-4 has been rehabilitated.

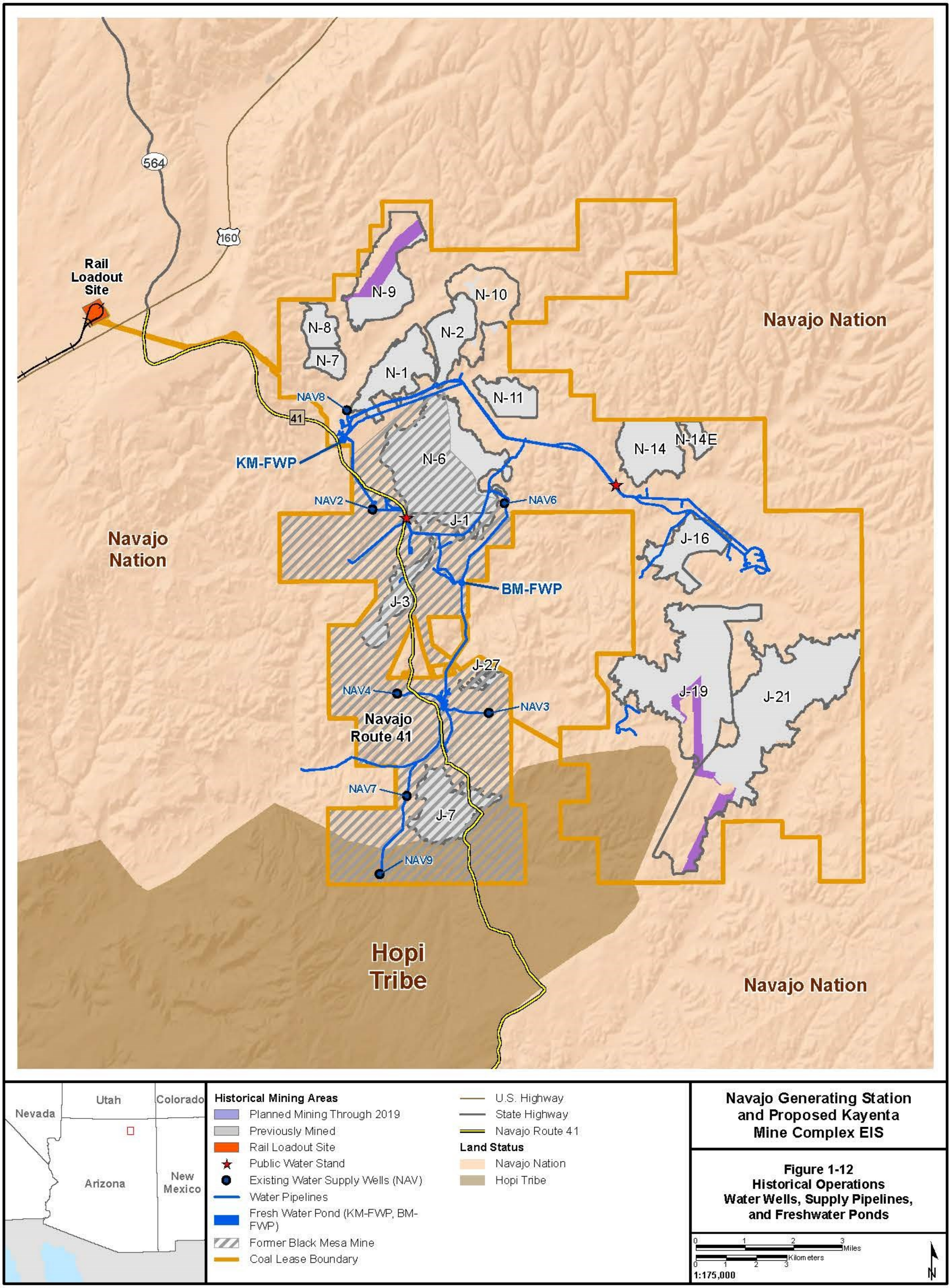

Figure 1-12
Historical Operations Water Wells, Supply Pipelines, and Freshwater Ponds

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The Mine Safety and Health Administration requires further engineered designs, construction, inspections, and maintenance for dams that meet greater height and/or storage capacity criteria in 30 CFR Part 77.216. PWCC has constructed and operated nine impoundments at the Kayenta Mine that meet the MSHA criteria. Storage capacities of the MSHA impoundments at Kayenta Mine range from approximately 22 to 724 acre-feet.

Stream channel diversions were constructed to maintain surface hydrologic conditions while facilitating removal of the coal resource. Under SMCRA permit AZ-0001C, PWCC constructed five diversions in the early 1980s. The original five are all on ephemeral stream reaches at the Kayenta Mine. One of these, along Coal Mine Wash, trends along the boundary between the Kayenta Mine and the former Black Mesa Mine. An additional diversion was constructed in 1993. This sixth diversion was designed and built to be a permanent feature on Reed Valley Wash on the northern boundary of the J-19 coal resource area at Kayenta Mine, and it is classified as an intermittent stream section. All of these structures have been designed, built, and maintained according to standard hydrologic and hydraulic engineering practices, and approved through applicable regulatory programs.

1.7.2.1.3 Roads

Roads within or crossing the mine permit areas are classified in four categories: Primary roads, ancillary roads, ramps (or routes of travel which are within the mining and spoil grading areas), and non-mining related roads (public and private) (**Figure 1-11**). Public roads are roads constructed for public use and financed, maintained, and administered by a government entity. There are two public roads which lie within or in close proximity to the Kayenta Mine and former Black Mesa Mine areas. U.S. Highway 160 lies north of the Kayenta permit boundary. Navajo Route 41 crosses through the Kayenta permit boundary and areas of the former Black Mesa Mine and provides access to U.S. Highway 160 to the north and Navajo Routes 4 and 65 to the south.

1.7.2.1.4 Fuel, Vehicle and Equipment Maintenance, and Explosive Materials Storage

Fuel and related petroleum products stored on-site for use include unleaded gasoline, diesel and Jet A-fuel, and lubricants. Maintenance-related products and spent products that are handled, stored, and used include antifreeze, solvents, lubricating oils, and greases. Bulk lubricants are delivered in 55-gallon drums or trucked in and delivered to aboveground storage tanks. Fuels are delivered by common carrier via tanker truck and are stored at both the Kayenta Mine and support facilities at the former Black Mesa Mine. These products are stored in aboveground storage tanks which are protected by primary and secondary containment. There are no underground storage tanks at the former Black Mesa Mine or Kayenta Mine. In addition, a portion of the diesel fuel stored at the Kayenta Mine area is mixed with ammonium nitrate to form an ammonium nitrate and fuel oil mixture, which is used for blasting overburden, parting, and coal in the mine areas.

PWCC maintains Spill Prevention, Control, and Countermeasure and Emergency Procedures plans describing measures to prevent fuel oil discharges and emergency response to mitigate impacts of any spills. The plans are reviewed and updated as needed, but at least once every 5 years and within 6 months of any change in facility design, construction, operation, or maintenance that materially affects the spill potential of the facility.

Blasting operations at the Kayenta Mine are conducted according to federal law, applicable regulations, and the approved permit. See **Appendix 1D** for a description of strategies to protect the public and livestock from blasting activities and Section 3.14 for information related to residential notifications and pre-blasting surveys.

1.7.2.1.5 Solid and Hazardous Waste Disposal

No disposal of solid wastes currently occurs within the PWCC mine leasehold boundary. PWCC contracts with a solid waste vendor to haul the solid waste off-site to a regulated landfill. No hazardous chemical wastes, radioactive materials, hazardous sludges and liquids, or any other type of hazardous waste are discarded within the entire leasehold area. All regulated wastes, as defined by the Resource Conservation and Recovery Act and other regulations, are shipped off-site for recycle or disposal in accordance with applicable federal, tribal, and state regulations.

Hydrocarbon-contaminated soil was discovered during excavation and removal of underground storage tanks at both the Kayenta Mine and former Black Mesa Mine areas. PWCC constructed an on-site bioremediation facility, referred to as a land farm, east of the J-16 mining area to remediate the contaminated soil. The land farm was managed in accordance with USEPA and NNEPA requirements. The bioremediation process has been completed, and NNEPA approved the final closure reports on May 14, 2014. PWCC will reclaim the land farm area in accordance with the approved reclamation plan.

1.7.2.1.6 Airfield

PWCC maintains a private airfield and associated facilities within the former Black Mesa Mine permit area, as one of the facilities used by the Kayenta Mine. The airfield is located on the surface of reclaimed mine area J-3 and consists of a 7,500-foot-long by 75-foot-wide asphalt paved runway, a small airplane tie-down ramp area, taxiway, aviation fuel storage area, and storage building. The airfield is typically used only during daylight hours but is equipped with runway lights that can be used for an emergency night landing. The facility was designed, constructed, and is maintained to comply with applicable local and federal regulations.

1.7.2.1.7 Air Quality Control and Monitoring

Key operations and activities in the pit areas subject to air quality control and monitoring include:

- Overburden and coal drilling and blasting;
- Overburden removal by dragline, backhoe, and loader;
- Coal removal by front-end loader or backhoe;
- Topsoil removal by scrapers;
- Road maintenance by graders;
- Dozer activity;
- Truck haulage of overburden;
- Truck haulage of coal from the pit area to the prep area; and
- Natural wind erosion of disturbed areas.

Other key operations outside of the pit area include:

- Coal preparation;
- Coal crushing; and
- Coal conveyance.

A summary of emission sources, control technologies, and the effectiveness of these technologies is provided in **Appendix 1D**.

Air emissions from Kayenta Mine operations are highly dependent on the location of ongoing mining, and result from a range of operations considered to be sources of fugitive emissions. Kayenta Mine overburden and coal removal occur at three coal resource areas. Coal removed from the northern coal resource area (N-9) is hauled by truck to the N-11 coal preparation area (prep area), where it is crushed, screened and transferred by conveyors to the N-8 prep area. Coal removed from the southern coal resource areas (J-19 and J-21) is hauled by truck to the J-28 prep area where it is crushed, screened, and conveyed to the N-8 prep area. The conveyors are covered, but not fully enclosed. The majority of transfer points on the conveyor system are fully enclosed. **Figure 1-10** provides an overview of the mining areas that will be active through 2019 at the Kayenta Mine.

Air quality and meteorological monitoring are conducted both at the Kayenta Mine and the former Black Mesa Mine. There are three separate meteorological monitoring sites, nine precipitation monitoring sites, and 14 separate air quality monitoring sites for particulate matter with an aerodynamic diameter of 10 microns or less. They are located on both the Kayenta Mine and former Black Mesa Mine areas. **Figure 1-13** depicts the locations of the separate monitoring sites.

1.7.2.1.8 Regulatory Jurisdiction and Bonding Requirements

The Kayenta Mine is required to have all mine plans approved by the OSMRE as the regulatory authority for coal mining and reclamation on Native American lands. Mine reclamation falls into one of three programs depending on when disturbance occurred; Pre-law, Initial Program, or Permanent Program. Pre-law lands are those that were disturbed prior to December 16, 1977, and have not been re-disturbed since. This is prior to the passage of the SMCRA and the effective date for Initial Program regulations, and Pre-law requirements pursuant to the lease terms pertain to reclamation of these lands. Initial Program lands are those that were disturbed between December 16, 1977, and the issuance of the Permanent Program permit for the Kayenta Mine in 1990. Mine reclamation must meet the requirements of the SMCRA and the Initial Program for Native American lands. Permanent Program lands are those lands disturbed after the issuance of a Permanent Program permit issued by the OSMRE pursuant to the SMCRA regulations. Lands that are disturbed under the Permanent Program permit are subject to the performance bonding requirements of the Permanent Program as described in 30 CFR Part 800. The amount of the performance bond is determined by OSMRE based on the requirements of the approved permit and reclamation plan. The amount must be sufficient for OSMRE to complete the reclamation work hiring a third party contractor. As reclamation is completed on Permanent Program affected lands, PWCC can request release of all or a portion of the performance bond through OSMRE.

Section 3.14, Land Use, provides Pre-law, Initial Program, and Permanent Program acreages. All future permitting would occur under the Permanent Program. Section 3.14 also discusses reclamation requirements and status of reclamation for Initial Program and Permanent Program affected lands. The bond release process and status for Permanent Program lands also is discussed. **Figure 3.14-1** shows the status of reclamation for the KMC.

1.7.2.1.9 Abandonment/Decommissioning

Decommissioning of mine facilities occurs when facilities are no longer required to support mining activities, unless the facility has been approved by OSMRE as a permanent facility. No facility decommissioning has occurred or would occur through 2019.

1.7.2.1.10 Community Programs

As part of its community liaison efforts, PWCC is active in programs at the Kayenta Mine to relocate residences in areas located near future blasting areas or within coal recovery areas (see the Relocation and Compensation subsection of Socioeconomics - Section 3.18). In addition, PWCC provides emergency medical services, access to potable water, water hauling for livestock, snow removal on area roads, coal, firewood, and managed grazing. Coal is made available (free or at a cost) to members of the community, and as areas on the mine are cleared for mining, firewood is made available from slash piles. Managed grazing on reclaimed lands is provided to some residents.

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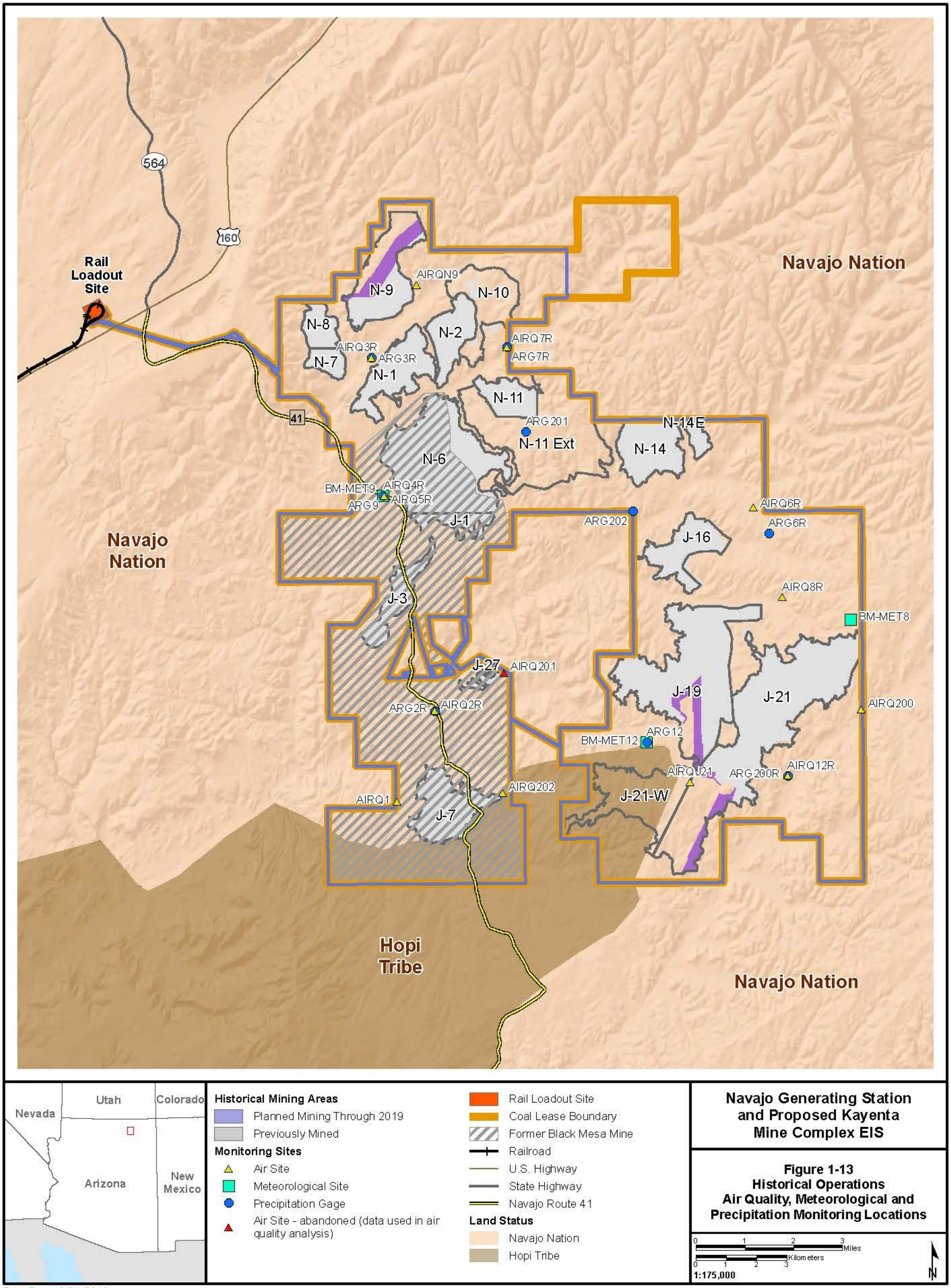

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Figure 1-13
Historical Operations
Air Quality, Meteorological and Precipitation Monitoring Locations

Print Date: 8/31/2016

PWCC provides two water stands where local residents can obtain potable water for personal use: the first is located along Navajo Route 41 just south of the Mesa Central Complex within the former Black Mesa Mine area, a second stand is located west of the N-14 facilities. Approximately 30 to 40 acre-feet of water is provided to the community from these water stands on an annual basis. PWCC currently is working with the Navajo Nation to provide water for a community water system known as the Many Mules Water Project adjacent to the Kayenta Mine. PWCC also is working to put in place the necessary agreements to provide water from the mine water distribution system and other necessary infrastructure to the Navajo Nation and the Hopi Tribe at the conclusion of mining.

PWCC periodically opens slash piles from clearing an area being prepared for mining at the Kayenta Mine, to allow firewood gathering by the local community. The community is notified by signage indicating the location and timing to gather firewood from the controlled locations where the slash is stored.

PWCC makes coal from the Kayenta Mine available to individuals in the local area; some coal is provided free while other coal is provided at cost. Coal is provided free to employees, individuals living in close proximity to the mine, and financially disadvantaged community members. Tribal Chapters may obtain coal for distribution, typically to disadvantaged or elderly members of the chapter. Individuals who are given or sold coal are provided with a pamphlet on the proper usage to minimize indoor air emissions.

Although not required to open reclaimed areas for grazing, PWCC evaluates plant biomass annually and determines if reclaimed areas can support grazing and, if so, the amount and duration of grazing the area can support. Managed grazing is allowed on up to 11,400 acres, which have vegetative cover to support grazing. PWCC cooperates with the local Tribal Chapters to encourage appropriate use levels and to provide preference to families with historic grazing rights in the area. Due to drought and overgrazing conditions, PWCC temporarily suspended livestock grazing in 2015 to improve range conditions and has indicated it will likely reinstate grazing in the future during average or better years.

Under the Initial Program for the Kayenta Complex, PWCC consults with OSMRE, BIA, and landowners to determine when an area is ready for grazing per 30 CFR Part 715.20(e)(2) which specifies: the regulatory authority, in consultation with the permittee and the landowner or in concurrence with the governmental land managing agency having jurisdiction over the surface, shall determine when the revegetated area is ready for livestock grazing. No grazing consultation/approval requirements for the Permanent Program lands are found under 30 CFR Part 816. PWCC currently provides water sources for stock watering through installation of temporary and permanent impoundments. These ponds are located throughout the mined areas.

1.7.2.2 Former Black Mesa Mine and Mine Support Facilities

1.7.2.2.1 Mining and Mining Support Facilities

The former Black Mesa Mine supplied coal to the Mohave Generating Station, located near Laughlin, Nevada, from 1970 to December 2005. PWCC suspended mining operations in December 2005 due to the closure and decommissioning of the Mohave Generating Station. Previously mined areas of Black Mesa Mine have been reclaimed, but not all support facilities associated with the mine areas, such as sedimentation ponds and roads, have been fully reclaimed. No new mining is planned for the former Black Mesa Mine.

1.7.2.2.2 Mine Support Facilities Used for Kayenta Mine

Some support facilities at the former Black Mesa mine currently are used to support mining at the Kayenta Mine and will continue to be used to support operations at the Kayenta Mine through 2019 (see **Tables 1-6** and **1-7**). These facilities are located on approximately 566 acres of the former Black Mesa Mine.

1.7.2.2.3 Support Facilities Not Used for Kayenta Mine

Support facilities at the former Black Mesa Mine not being used for the Kayenta Mine include the Black Mesa Mine truck shop, warehouse, and foreman offices; welding shop; electrical shop; bath house; administration building; coal-handling facilities; coal laboratory; quonset hut; and ready-line and compressor house. Former Black Mesa Mine facilities not being used by the Kayenta Mine, if not requested by the Navajo Nation for their use, will be reclaimed.

A portion of the existing, inoperable coal slurry pipeline and water storage tank associated with the Black Mesa Pipeline facilities are located within the former Black Mesa Mine area. Approximately 200 feet of the pipeline lies within the mine area boundary as the pipeline corridor extends away from the former Black Mesa Pipeline facilities. The pipeline is inoperable and is not part of PWCC's existing and approved operations. Additionally, the Black Mesa Pipeline facilities are not owned by PWCC, are not part of PWCC's existing operations through 2019, and are not part of the Proposed Action. Plans for reclaiming these facilities by the facility owner currently are under review by OSMRE.

1.7.2.2.4 Water Use and Management

As previously discussed, mine water supply production wells NAV-2 through NAV-4, NAV-7, and NAV-9 are on the former Black Mesa Mine area and comprise part of the pumping operations to provide water for use and hydrologic monitoring at the Kayenta Mine. These groundwater withdrawals are pumped through water lines to storage tanks, collection ponds, and water stands located in the former Black Mesa Mine area or at roadside distribution points. The Black Mesa Mine fresh water pond also is located near the Black Mesa Reclamation Complex.

There are approximately 49 sedimentation structures and impoundments constructed on the former Black Mesa Mine operations area. All of these features have been designed, built, and operated in accordance with federal regulations and current permit provisions. Approximately 31 of the temporary structures have been reclaimed. Approximately 12 permanent impoundments are to remain on reclaimed surfaces within the former Black Mesa Mine operations area at the end of 2019 to provide post-mining stock watering use and habitat. These structures have been identified in consultation with OSMRE and Navajo Nation Water Resources staff.

There are approximately 48 National Pollution Discharge Elimination System outfalls (discharge locations) for PWCC operations at the former Black Mesa Mine operations area that can be organized into the following three categories based on types of disturbance and their discharges:

- Alkaline Mine Drainage (19 outfalls);
- Coal Preparation Plants, Storage Areas, and Ancillary Area Runoff (9 outfalls); and
- Western Alkaline Reclamation, Brushing and Grubbing, Topsoil Stockpiling, and Regraded Areas (20 outfalls).

PWCC has constructed and operated two impoundments on the former Black Mesa Mine that meet MSHA criteria. These structures have been designed, built, and maintained in accordance with regulations. Total storage capacities of the MSHA impoundments range from 179 to 669 acre-feet.

Stream channel diversions were constructed to maintain surface hydrologic conditions while facilitating removal of the coal resource. Under SMCRA permit AZ-0001C, PWCC constructed five diversions in the early 1980s. All of these except the Coal Mine Wash diversion are within the Kayenta Mine operations area as previously described. The Coal Mine Wash diversion trends along the boundary between the former Black Mesa Mine and Kayenta Mine boundaries. This feature has been designed, built, and maintained according to standard hydrologic and hydraulic engineering practices, and approved through applicable regulatory programs.

1.7.3 Transmission Systems and Communication Sites

Energy from NGS is delivered on 500-kV transmission lines on the WTS and STS (**Figure 1-14**) to points of delivery (Moenkopi switchyard and McCullough, Westwing, Yavapai, Cedar Mountain, Dugas, Morgan, and Crystal substations) for the NGS participants as specified in NGS operating agreements. The facilities comprising the transmission system (transmission lines, substations, and communication sites) all are part of the western electric grid and; therefore, all have independent utility (i.e., their renewals would be sought even in the absence of NGS).

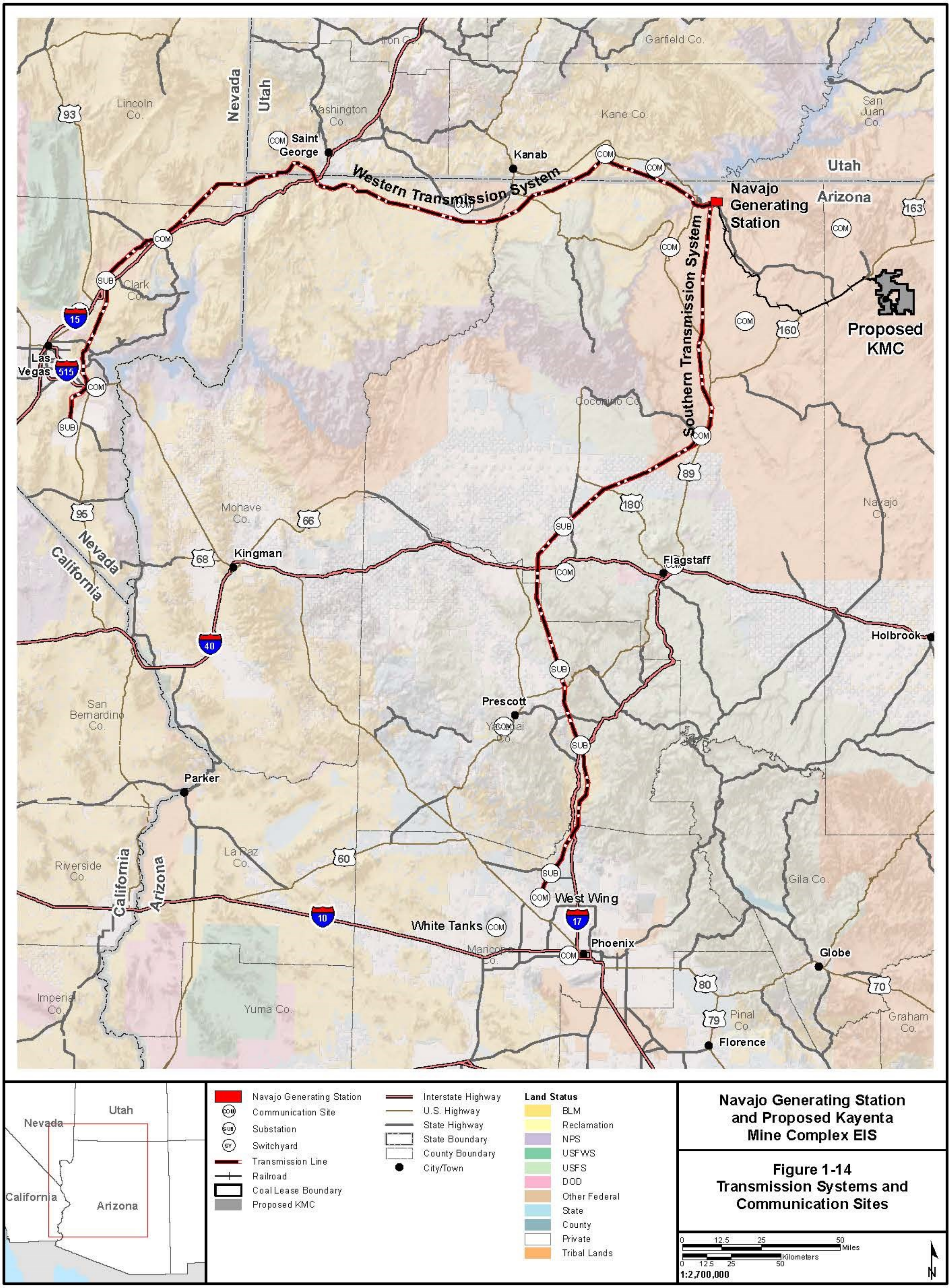
The WTS is administered by the Los Angeles Department of Water and Power and on-the-ground operation and maintenance is performed by NV Energy. The power line begins at NGS east of Page, Arizona, and generally heads west along the Utah-Arizona border. From there it turns to the southwest into Nevada through the BLM-administered Moapa Corridor that traverses through the Moapa Indian Reservation, through to the Crystal substation located northeast of Las Vegas. It turns south at the Crystal substation and continues to its terminus at the McCullough substation located approximately 14 miles southwest of Boulder City, Nevada. The total line distance in Arizona, Utah, and Nevada is 275 miles and occurs across various land owners as shown in **Table 1-9** and detailed in **Appendix 1B**.

The STS is operated and maintained by Arizona Public Service. This transmission system consists of two parallel, high-voltage transmission lines that begin at NGS east of Page, Arizona. The eastern line is referred to as the Westwing Line and the western line is referred to as the Moenkopi Line (together the parallel lines are often referred to by Arizona Public Service as the “500-2” line). The Moenkopi Line connects to the Moenkopi switchyard and Cedar Mountain and Yavapai substations and terminates at Westwing substation. The Westwing Line connects to the Dugas and Morgan substations and terminates at the Westwing substation. Except for a small segment near Moenkopi, the lines are within a common corridor (ROW). The total STS power line distance in Arizona is 256 miles and occurs across various land owners as shown in **Table 1-9** and detailed in **Appendix 1B**.

Table 1-9 Surface Ownership/Management for Lands Crossed by WTS and STS

Ownership/Management by State	WTS (miles)	STS (miles)	Total (miles)
Arizona Total	**121**	**256**	**377**
Bureau of Indian Affairs	6	96	101
Bureau of Land Management	87	27	115
Bureau of Reclamation	-	1	1
National Park Service	3	-	3
Private Land	12	20	33
State	12	47	59
U.S. Department of Agriculture Forest Service	-	65	65
Nevada Total	**109**	**-**	**109**
Bureau of Indian Affairs	14	-	14
Bureau of Land Management	81	-	81
Bureau of Reclamation	7	-	7
Private Land	8	-	8
Utah Total	**45**	**-**	**45**
Bureau of Land Management	33	-	33
Private Land	0	-	0
State	12	-	12
Grand Total	**275**	**256**	**531**

Note: Numbers rounded for presentation and individual rounded numbers may not equal the numbers presented as totals.



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 1-14
Transmission Systems and Communication Sites

There are six substations/switchyards interconnected to the STS and two on the WTS, besides the commonly shared switchyard at the NGS plant. The specific infrastructure and equipment contained within each site varies, but generally each switchyard or substation contains power transformers; switching devices such as circuit breakers and disconnects to cut power; and measurement, protection, and control devices needed to ensure its safe and efficient operation. There is an access road into each site, and all sites are surrounded by security fencing. Repairs and maintenance occur within the existing footprint.

The 19 communication sites, which support operations of the plant, railroad, and transmission systems, are shown on **Figure 1-14**. The communication sites are located within the boundaries of the NGS, substations, or in remote locations that are at sufficient elevations to facilitate line-of-sight transmission to one or more other sites. Redundant power is installed at the NGS and substations to back up the communication equipment; propane fueled generators provide backup power at remote sites. Remote sites are fenced, and many of the sites are co-located with other users' equipment. Operation and maintenance, installation and replacement of equipment, and access are coordinated with those other users.

Inspections, maintenance, and repair of the communication sites are conducted on an as-needed basis, usually once a year or less. Typical maintenance activities include: building and antenna structure repair and maintenance, communication equipment maintenance and upgrades, clearing of vegetation within the site grounds and at fence line to prevent fires, roof repair and replacement, replacement of weathered cables, and repair of access roads (**Appendix 1B**).

1.8 Relationship of this Proposed Action to Other Activities

1.8.1 U.S. Environmental Protection Agency Actions

The Clean Air Act, passed by Congress in 1970, was amended in 1977 to include the Regional Haze Rule to reduce haze and pollution that decrease visibility. In August 2014, the USEPA promulgated a Federal Implementation Plan for implementing the Regional Haze Rule to reduce NO_X emissions at NGS that can contribute to regional haze at 11 Class I areas (e.g., National Parks, wilderness areas) within a 300-kilometer radius surrounding the NGS. In the view of the NGS Participants, USEPA's originally proposed Best Available Retrofit Technology (BART) rule may have resulted in the NGS Co-tenants shutting down the plant for economic reasons. The BART Federal Implementation Plan rule was consistent with a "better than BART" proposal submitted to USEPA as part of an agreement developed by a group of stakeholders known as the Technical Work Group. The Technical Work Group included SRP on behalf of the NGS Co-tenants, the U.S. Department of the Interior, Central Arizona Water Conservation District, the Navajo Nation, the Gila River Indian Community, the Environmental Defense Fund, and Western Resource Advocates. This diverse group of stakeholders was committed to finding an operational approach that would allow the continued operation of NGS, and includes commitments by the U.S. Department of the Interior to reduce air emissions and study opportunities to transition the federal share of NGS from coal over time. The BART Federal Implementation Plan includes provisions to shut down one unit by 2020—or operate the NGS plant with NO_X emissions equivalent to a one-unit shut down—and install selective catalytic reduction or equivalent technology on the operating units by 2030. This EIS incorporates implementation of the Federal Implementation Plan under the Proposed Action and all action alternatives, since implementation of the plan would occur post-2019.[14] More information about the Regional Haze Rule Federal Implementation Plan and the Technical Work Group Agreement is provided in **Appendix 1C**.

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[14] As of the release date of this document, the Regional Haze Rule Federal Implementation Plan has been challenged in four legal proceedings, which have been consolidated and are currently in the U.S. Court of Appeals for the Ninth Circuit. The outcomes are pending and their status will be updated as new information is available.

Pursuant to the Clean Air Act, Section 111(d), USEPA published a final “Clean Power Plan” on October 23, 2015 (80 Federal Register 64662), that would regulate carbon emissions from existing utility-sized fossil-fuel fired generating units within the lower 48 states, and located on tribal lands of the Navajo Nation, Ute Indian Tribe, and Fort Mojave Indian Tribe. The rule establishes an ultimate 2030 emission performance limit for each jurisdiction subject to the rule, plus interim emission limits beginning in 2022 to provide for a transition to the more stringent 2030 emission performance limits. The 2030 performance limits are designed to reduce carbon emissions nationally by 32 percent compared to 2005 emission levels. The final plan would require a state or tribe to use an emission rate-based performance plan (pounds/megawatt-hours) or alternately, a mass-based performance plan (tons carbon dioxide emitted per year). States must have approved plans by 2018, and must implement their approved plans to meet their respective interim and final emission limits starting no later than 2022. A tribe with one or more affected electric generating units located on its lands will have the opportunity, but not the obligation, to apply for eligibility to develop a Clean Air Act Section 111(d) implementation plan. The tribe would need to be approved by the USEPA as eligible to develop and implement a Clean Air Act Section 111(d) plan pursuant to Clean Air Act Section 301(d) and the procedure set forth in 40 CFR Part 49. If the tribe does not have an adequate implementation plan, for whatever reason, USEPA will implement federal implementation plan provisions if USEPA finds it necessary or appropriate to do so under 40 CFR Section 49.11.[15]

USEPA has not yet made a final determination as to whether or not it is necessary or appropriate to directly implement the final Clean Power Plan on Navajo Nation lands, should the Nation choose not to seek a tribal implementation plan under Section 111(d) and 40 CFR Part 49.

For more information on this final rule, see: https://www.epa.gov/ cleanpowerplan/clean-power-plan-existing-power-plants#federal-plan.

The effect of the Clean Power Plan on future operations at NGS is currently unknown, pending resolution of legal challenges to the rule, as well as a final determination regarding implementation of the Clean Power Plan on Navajo Nation lands.

1.8.2 Joint Federal Agency Work Group

On January 4, 2013, the U.S. Department of the Interior, USEPA, and the Department of Energy issued a “Joint Federal Agency Statement” regarding NGS, which commits the three agencies to work together toward goals that produce:

> ...(i) clean, affordable and reliable power; (ii) affordable and sustainable water supplies, and (iii) sustainable economic development, while (iv) minimizing negative impacts on those who currently obtain significant benefits from NGS, including tribal nations. (Joint Federal Agency Statement 2013)

[15] On February 9, 2016, the U.S. Supreme Court granted a stay on the Clean Power Plan stopping implementation pending disposition of legal challenges in the U.S. Court of Appeals for the District of Columbia Circuit.

A federal NGS Working Group was formed to oversee the activities undertaken in support of the Joint Federal Agency Statement, which include collecting sound, scientifically based information on issues relating to the NGS for the federal government, and helping the three agencies work with stakeholders to develop a roadmap for the long-term future of NGS.

National Renewable Energy Laboratory, part of Department of Energy, issued a Phase 1 Report in January 2012 entitled "Navajo Generating Station and Air Visibility Regulations: Alternatives and Impacts" under an Interagency Agreement between U.S. Department of the Interior and Department of Energy. The purpose was to address in one study, information on all the issues affecting NGS for the USEPA to consider in its development of the BART proposed rule for NGS. A second report under Phase 1 on clean energy alternatives, the "Navajo Generating Station and Clean-Energy Alternatives: Options for Renewables," was published by National Renewable Energy Laboratory in June 2012 to lay the groundwork for further research on clean energy alternatives to NGS (National Renewable Energy Laboratory 2012a,2012b. See Section 2.3.1.1 for additional discussion.

The National Renewable Energy Laboratory continues work with a series of proposed studies referred to as the "National Renewable Energy Laboratory Phase 2 Study." The National Renewable Energy Laboratory Phase 2 Study, which is funded and overseen by Reclamation, assumes post-2019 operations of NGS and investigates actions that could be taken to replace the energy associated with the federal share in NGS. The National Renewable Energy Laboratory Phase 2 Study will define a portfolio of clean energy and non-coal generation alternatives that minimizes negative impacts to those who currently obtain significant benefits from NGS in a glidepath to operate the CAP after 2044.

In support of the goals of the Joint Federal Agency Statement, Reclamation is working with Native American tribes affected by the Proposed Action. Reclamation has entered into a cooperative agreement with the Navajo Nation to assist in the preparation of a Navajo Clean Energy Development Plan, which will be used to advance the Navajo Nation's Clean Energy Policy. Reclamation and the Hopi Tribe are entering into a cooperative agreement to assist in developing a Hopi Clean Energy Strategic Plan. Reclamation and the Gila River Indian Community (GRIC) are entering into a cooperative agreement to assist in developing a GRIC Renewable Energy Study. The tribal clean energy studies will inform the NGS roadmap, identify tribal clean energy economic development opportunities and renewable energy options to replace a portion of NGS energy for the CAP.

Other initiatives are being pursued, as well. One such tribal technical assistance initiative is being undertaken by the National Renewable Energy Laboratory, Reclamation, Western Area Power Authority and the Northern Arizona University, to formulate an inter-tribal renewable energy marketing mechanism.

1.8.3 California and Nevada Legislation Regarding Use of Fossil Fuels

As noted in Section 1.1, the Los Angeles Department of Water and Power executed an asset purchase agreement with SRP on July 1, 2016. This agreement was initiated as a result of California State Senate Bill 1368, which limits long-term investments in baseload generation by California utilities to power plants that meet certain emissions performance standards. Under the asset purchase agreement, SRP acquired Los Angeles Department of Water and Power's 21.2 percent interest in NGS generation through 2019. After 2019, this amount of power and energy will no longer be generated at NGS. Los Angeles Department of Water and Power intends to continue participation in the NGS transmission systems and communication sites and to continue transmission of electricity generated from other sources.

Nevada State Senate Bill 123 requires certain Nevada utilities to develop a plan to reduce emissions from coal-fired electric generating plants and calls for the replacement of the capacity of such plants with increased capacity from renewable energy facilities and other electric generating plants. Pursuant to State Senate Bill 123, NV Energy will be divesting its 11.3 percent generation interest in NGS by December 31, 2019. NV Energy currently intends to continue receiving its share of NGS generation through December 22, 2019. A separation agreement between NV Energy and the remaining NGS Participants is anticipated to be executed prior to that date. NV Energy has expressed its intentions to continue participating in the NGS transmission systems and communication sites beyond 2019, and to continue transmission of electricity generated from other sources. Decisions by NV Energy on how and when it would exit from its participation in the NGS plant could affect the manner in which compliance with the Regional Haze Rule's Federal Implementation Plan is undertaken at NGS and its timing. Such decisions could also affect the form of any continuing lease of the plant site with the Navajo Nation (a lease amendment if all of the current Co-Tenants continue as owners or, alternately, a new lease agreement among the Navajo Nation and the continuing NGS owners only). In the event of a new lease, the terms of such agreement would be substantively similar to those in Lease Amendment No 1.

1.8.4 Navajo Nation Option to Acquire an Ownership Interest in Navajo Generating Station

Lease Amendment No. 1 would provide a right of first refusal and purchase options for the Navajo Nation to acquire up to 170 MW of generating capacity in the event of specified divestiture actions. The divestiture by Los Angeles Department of Water and Power on July 1, 2016, triggered the buy-in option for the Navajo Nation. A decision by the Navajo Nation to exercise the option could result in changes in the shares of generating capacity available to other Co-tenants. As discussed in Section 1.8.3 above, there are current unknowns associated with NV Energy's exit from NGS.

The results of ownership changes brought about Los Angeles Department of Water and Power, NV Energy, and Navajo Nation purchases and sales would primarily affect the allocation of capacity to each NGS Participant, but not the upper and lower limits of production (the range is described in Section 2.3.1). Therefore, the analysis takes into account the possible range of ownership scenarios after 2019, all of which fall within the upper and lower limits of production.

1.8.5 Navajo Nation Primacy

Currently OSMRE is, and would remain the primary regulator of coal mining under the SMCRA until the Navajo Nation demonstrates that it has developed a regulatory program that meets all of the requirements in the SMCRA and implementing regulations issued by OSMRE.

If the Navajo Nation submits and receives approval of its proposed regulatory program from OSMRE, it would become the primary regulator within the Navajo Nation reservation lands and would assume responsibility over permitting, inspection, and enforcement activities for coal mining activities. OSMRE then would provide oversight of the Tribe's implementation of the regulatory program.

The date of enactment of the Navajo Nation SMCRA is the critical date that drives the schedule for submission and approval of the Navajo regulatory program. The Navajo Nation is hopeful that it can bring the Act before the Navajo Nation Council for approval in 2016; if approved, the Act would likely take effect in 2017.

1.9 Government-to-government Consultations

Pursuant to Executive Order 13175 (Consultation and Coordination with Indian Tribal Governments), the Department of the Interior has conducted government-to-government tribal consultation as detailed in **Table 1-10**. Additional government-to-government tribal consultations and informal tribal consultations will occur at key project stages and as requested by tribal governments.

Table 1-10 Government–to–Government Tribal Consultations to Date

Tribe	Date	Location	Agencies Represented
Navajo	March 31, 2014	Window Rock, AZ	Reclamation, OSMRE, BIA-Navajo Region
	July 21, 2015	Window Rock, AZ	Reclamation, OSMRE, BIA- Navajo Region
	July 19, 2016	Window Rock, AZ	Reclamation, OSMRE, BIA- Navajo Region
Hopi	May 16, 2014	Kykotsmovi, AZ	Reclamation, OSMRE
	May 15, 2015	Kykotsmovi, AZ	Reclamation, OSMRE
	March 7, 2016	Kykotsmovi, AZ	Reclamation, OSMRE
	June 22, 2016	Kykotsmovi, AZ	Reclamation, OSMRE, BIA- Western Region
CAP-affected Tribes	May 15, 2014	Phoenix, AZ	Reclamation, BIA- Western Region
	April 14, 2015	Phoenix, AZ	Reclamation
Kaibab Band of Paiute Indians	July 3, 2014	Pipe Spring, AZ	Reclamation, OSMRE, BIA- Western Region
	April 16, 2015	Pipe Spring, AZ	Reclamation
	February 18, 2016	Pipe Spring, AZ	Reclamation
Hualapai	March 4, 2016	Peach Springs, AZ	Reclamation
Pueblo of Zuni	February 16, 2016	Zuni, NM	Reclamation, OSMRE

1.10 Public Scoping

Scoping is defined in NEPA's implementing regulations (40 CFR Part 1501.7) as "an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to the proposed action." The following sections provide an overview of the scoping process, results, and the primary impact issues brought up during scoping that are addressed in the EIS.

1.10.1 Public Scoping Outreach Process

On May 16, 2014, Reclamation published a Notice of Intent in the *Federal Register* announcing the intent to prepare an EIS for the NGS-KMC Project. The Notice of Intent described the Proposed Action and alternatives under consideration, described public comment opportunities, and provided the locations, dates, and times of the open house scoping meetings. The Notice of Intent initiated the scoping period, which was scheduled to continue through July 7, 2014 (61 days).

Public outreach activities prior to the June public scoping meetings included advertisements and news releases placed in local and regional newspapers; a notification letter to government agencies, elected officials, and non-governmental organizations; postcards and newsletters distributed to a mailing list of over 760 entities; public service announcements aired on local radio stations in both the Navajo and Hopi languages; and meeting notification fliers and public information summaries distributed to Navajo chapter houses, Hopi community centers, and libraries in the project area. A community-based training video in English, Navajo, and Hopi languages also was made available on the NGS-KMC Project public website. This video provided a tutorial on the NEPA process and public involvement in the NGS-KMC Project EIS process.

1.10.2 Public Scoping Meetings

Reclamation held 10 public scoping meetings from June 10, 2014 to June 20, 2014 (see meeting locations and dates in **Appendix 1E**). The meeting sites were located to encourage participation from tribal governments, communities near the NGS and the proposed KMC, and water users in the CAP service area. The scoping meetings were held in an informal open house format where members of the public could arrive at any time during the published 3-hour time period. Two court reporters were available at each scoping meeting to record oral comments. At scoping meetings held on the Navajo and Hopi Reservations, Navajo and Hopi interpreters were available to assist attendees in conversing with project team members and to help interpret oral comments made to the court reporters.

A project video was developed and made available at each scoping meeting in English, Navajo, and Hopi languages to provide an overview of the NEPA process, public involvement opportunities, and suggestions on how to provide substantive comments on the Proposed Action and environmental resource areas that should be considered in the analysis.

An additional poster station overview handout, comment form, and fact sheet were supplied for the informal conferences, required by SMCRA regulations for the Kayenta Mine permit revision application. These informal conferences were held by OSMRE concurrently with the Reclamation open house scoping meetings at Forest Lake Chapter, Kayenta, and Kykotsmovi.

1.10.3 Additional Meetings on the Hopi Reservation

At the request of the Hopi Tribe, Reclamation reinitiated and extended the public scoping comment period by publishing a *Federal Register* notice on July 25, 2014, announcing extension of the public scoping comment period through August 31, 2014. This extension provided an opportunity for expansion of public involvement activities including community outreach meetings and an additional scoping meeting on the Hopi Reservation.

Public outreach activities (similar to those conducted in June 2014) were completed prior to the August 2014 public scoping and community meetings. Two community outreach meetings plus an additional scoping meeting were held in August 2014 on the Hopi Reservation to respond to a request from the Hopi Tribe to provide additional opportunities to obtain information and to comment. The format and the information presented at the community outreach and scoping meetings were the same and matched the format of the 10 open house scoping meetings held in June 2014. Written comments were accepted at all three meetings. Attendees were notified that comments could be submitted by mail, fax, or email; court reporters were present to record oral comments from the public only at the August 14 scoping meeting.

1.10.4 Public Scoping Participation

Meeting attendees were encouraged to sign in at the welcome table. In total, 228 people signed in at the June open house scoping meetings; 45 people signed in at the supplemental August 2014 meetings on the Hopi Reservation.

1.10.5 Public Scoping Comments

Scoping comments were submitted by the public in several different ways: at scoping meetings in the form of written (hand written or typed submissions or completed comment forms) or oral submission (recorded by court reporters as verbatim transcripts); as emails or attachment to emails sent to NGSKMC-EIS@usbr.gov; in written format (letters) delivered via U.S. mail or other delivery method, or as a memorandum from another federal agency.

After comments were received, each submittal was reviewed to identify the comments that could best assist the EIS team to determine issues to be analyzed in the EIS or to gather information that would be useful as background information for the analysis.

The individual comments were then assigned one or more classifications, based on their content, and entered into a database. Each comment in the database was attributed to the commenter (if known), the affiliation of the commenter (if stated), and associated in the database to the original submittal.

Table 1-11 provides the sources and numbers of comment submissions. Multiple comments were often provided in individual submissions.

Table 1-11 Commenter Type or Affiliation

Commenter Type/Affiliation	Number of Comment Submissions
Individual	66
Federal Agency	2
State or Local Agency	3
Non-governmental Organization/Special Interest	23
Business	4
Tribe	12
Total Comment Submittals	110

The public scoping report for this project is provided as **Appendix 1E** to this Draft EIS. Details on public outreach, information provided at scoping meetings, public participation summaries, and a detailed summary of the public comments received by resource topic are contained in the Scoping Summary Report. The Scoping Summary Report is available at http://www.ngskmc-eis.net.

1.11 Summary of Issues

The general theme of public scoping input was the tradeoff between the continued economic and social benefits of coal mining and lower-cost coal-fired power generation, and the adverse environmental and social effects of these activities. Public scoping comments reflected local community opinions about the past, current, and future operations of the individual project components (the power plant, the coal mine, and electrical transmission and distribution in central/southern Arizona). Comments also addressed broader national concerns related to the continued burning of coal as a contributor to regional haze and global climate change.

Concerns related to NGS focused on effects of plant stack emissions and fugitive dust from coal ash disposal areas, on local and regional air quality and ecological and public health. Natural gas, wind, and solar generation were endorsed as possible alternatives to replace or partially replace NGS operations. Several renewable energy alternatives located on tribal lands were suggested.

General concerns related to the Kayenta Mine included the effects to Black Mesa resulting from mining that individuals perceive as the cause of irreversible changes in Navajo and Hopi community sustenance, traditional uses, and religious experiences associated with certain places such as springs. The long history of mining on Black Mesa has resulted in several environmental and social issues that influence input to the current EIS process. The most frequently expressed historic concerns are the effects of past industrial uses of groundwater underlying Black Mesa, the treatment of cultural resources and burials within areas to be mined, and public health concerns related to fugitive dust from mining operations.

Because many Navajo and Hopi community members work as mine employees, live near active mining areas, and traverse part of the mine permit area on public and local roads, there is a constant engagement between the mine operator (PWCC) and the local community. This engagement was expressed in both positive and negative terms. The following are some specific issues of public concern related to mine operations:

- Effects of fugitive dust, blasting, and changes in surface water quality from mining operations on the health of residents living near the mine;
- The magnitude and duration of mine-related groundwater pumping effects on spring and channel flows, and on wells that support human and livestock use;
- Mine reclamation practices that meet the regulatory requirements, but also should consider and support traditional uses (wildlife, plants for cultural use and food, livestock);
- Active mining safety concerns that limit access by community members to water sources and grazing areas;
- The identification, treatment, and protection of archaeological resources, sacred sites, and burials on areas to be mined;
- The likelihood of relocation of residents living near the mine;
- The employment and economic benefits to the Navajo Nation and Hopi Tribe from mining; and
- Current and future status of public services provided to the local community by PWCC, including creation and access to surface water sources, public road maintenance, and provision of coal used for winter heating.

The major concern expressed by the Central Arizona Water Conservation District and some of the tribes that receive CAP water was the future cost of irrigation, municipal, and industrial water (from both surface water and groundwater sources) that would be delivered by electricity generated by NGS or other sources. Other concerns included potential changes in the Development Fund contributions that are provided by NGS surplus power generation sales and potential effects on future tribal water rights settlements that may involve CAP water.

Because of the large geographic area affected by the project components and the prior history of mining on Black Mesa, a variety of comments were received on the assessment of cumulative impacts of past, present, and future actions. Of particular concern were cumulative effects of both the generating station and mining operations on regional air quality, greenhouse gas emissions on a regional and national basis, and effects on groundwater resources underlying Black Mesa. As noted previously, many scoping participants wanted the effects of historic mining and groundwater withdrawals to be carefully and accurately considered in the cumulative effects analysis of this EIS. Other comments focused on the effects of current and future mining and groundwater withdrawals on future opportunities for community development on both the Navajo Nation and the Hopi Tribe.

Public scoping comments were synthesized into EIS issues to be addressed in each EIS chapter, and by resource topic (e.g., Air Quality, Water Resources). **Table 1-12** summarizes public scoping comments on the Proposed Action; alternatives that should be considered; and suggestions for the future operations of the NGS and the proposed KMC. **Table 1-13** provides a list of issues by resource, and identifies where the issue is addressed in the document.

1.12 Document Organization

The remainder of the EIS is organized into the following chapters.

Chapter 2.0 – This chapter provides a summary of the alternatives considered but eliminated, and the process that was implemented to develop action alternatives that are evaluated in the EIS. The Proposed Action, three action alternatives, and No Action Alternative are described in detail. A summary table is provided at the end of Chapter 2.0 to identify, by resource, the major characteristics of each alternative and summarize each alternative's impacts in a comparative format.

Chapter 3.0 – The introduction to Chapter 3 presents background information that is applicable across all resources and alternatives. This chapter is divided into sections specific to the environmental, social, and economic resources and conditions relevant to the project area. Each section briefly describes the "affected environment" for that resource, followed by a description of the direct, indirect, and cumulative impacts that are anticipated to result to that resource from implementation of the Proposed Action, three action alternatives, and No Action Alternative. The chapter introduction describes the organizational format that follows for each resource and provides background information regarding the methodology used in evaluating impacts described in the EIS.

Chapter 4.0 – This chapter summarizes by resource the measures that have been recommended for consideration to mitigate (avoid, reduce, or otherwise offset) impacts that have been identified in Chapter 3.0.

Chapter 5.0 – This chapter presents a discussion of the relationship between short-term uses of man's environment and maintenance and enhancement of long-term productivity.

Chapter 6.0 – This chapter identifies the irretrievable resources that would be lost and irreversible impacts that would occur, as a result of implementing the Proposed Action, the three action alternatives, and No Action Alternative. Irretrievable commitments apply primarily to the use of nonrenewable resources that cannot be replenished such as fossil fuels, paleontological and cultural resources. Irreversible commitments primarily result from the use or loss of a specific resource that cannot be replaced within a reasonable time.

Chapter 7.0 – This chapter describes the elements of consultation and coordination performed by the federal agencies during the development of this EIS. Topics include interaction with cooperating agencies, government-to-government consultation, and resource subgroup activities.

Chapter 8.0 – This chapter identifies the Preparers of this EIS.

Table 1-12 Public Scoping Comments on the Proposed Action and Alternatives Development

Topic	Affected Facility		Scoping Comment Summary
	NGS	Proposed KMC	
Proposed Action – NGS	X		The current operations continue at the NGS through 2019 in terms of coal delivery, storage, and power plant combustion; air pollution controls; make-up water supply and use; industrial chemical delivery and storage; fly and bottom ash disposal and sales; solid and liquid waste generation and disposal; and power plant employment. The future operational changes at the NGS (2020-2044) related to installation of new air pollution controls and resulting air emissions; industrial chemical delivery, storage, and use; make-up water use and disposal; ash disposal and sales; power plant employment. Decommissioning and removal of any facilities resulting from retirement of generation units. Ongoing regulatory compliance by current NGS operations for stack emissions, water supply, surface water and groundwater quality, and waste management. Environmental protection activities and compliance plans for future activities extending from 2020-2044.
Proposed Action – Kayenta Mine and Proposed KMC		X	The current operations continue at the Kayenta Mine through 2019 in terms of surface coal mining locations, methods, and coal volumes produced; status of land disturbance and reclamation; mine haul road systems and maintenance; coal conveyor and railroad loadout systems; soil and overburden management; revegetation programs and monitoring; alternative water supply for mine uses; fugitive dust controls; surface water runoff controls and maintenance; livestock grazing management; mine employment; bond requirements and release. The future operations at the proposed KMC permit area (2020-2044) related to the same topics described for current operations. Specific issues include incorporation of shared facilities into a new administrative boundary and realignment of a segment of Navajo Route 41 and maintenance. Ongoing regulatory compliance by current Kayenta Mine operations for air quality, water supply, surface water and groundwater quality, and waste management. Environmental protection activities and compliance plans for proposed KMC activities extending from 2020-2044.
Alternatives – development process	X	X	How EIS alternatives were developed and screened. How the tribes were involved in the development of project alternatives via government-to-government consultation. Application of alternatives screening factors: the future cost of electrical power for CAP pumping; capability to generate surplus power for the Lower Colorado River Basin Development Fund; transmission infrastructure limitations; grid interconnection opportunities.
Alternatives – different electrical power sources	X	X	Consider lower carbon dioxide emitting fossil-fuel or other sources (natural gas, nuclear) and renewable energy sources (wind, solar, hydroelectric). Renewable energy project locations were suggested on Navajo Nation, Hopi Tribe, Pascua Yaqui Tribe, and Gila River Indian Community reservation lands. Consider a full or partial NGS federal share replacement alternative that places a renewable energy project on reclaimed Black Mesa and Kayenta Mine lands as specified in the OSMRE settlement agreement. Consider the use of municipal waste sources as an alternative source of power for CAP.

Table 1-12 Public Scoping Comments on the Proposed Action and Alternatives Development

Topic	Affected Facility		Scoping Comment Summary
	NGS	Proposed KMC	
Alternatives – emissions controls	X	X	Consider clean coal technologies; opportunities for underground sequestration of carbon dioxide; immediate shut down of two units, with one unit remaining.
NGS Alternatives – Conservation	X		Consider Smart Grid technology to reduce power generation demand at NGS.
Facilities and permit boundary		X	Consider an alternative that includes only former Black Mesa Mine support facilities without expanding the proposed KMC boundary; consider an alternative that involves no addition of former Black Mesa Mine support facilities or lease area to the proposed KMC.
Future mining on Hopi lands		X	Consider an alternative that would avoid or limit coal mining on Hopi Reservation surface to protect cultural resources.
Mine water sources		X	Consider alternatives to obtain mine water from the C and D aquifers, or other surface water and groundwater sources, with a consequent reduction in withdrawals from the N-Aquifer.
No Action – potential replacement power sources	X	X	Possible purchase agreements/new sources of electrical power that could be acquired by the NGS owners and the Central Arizona Water Conservation District in the event that the NGS ceases to operate. Consider the opportunities for the complete replacement of the NGS with renewable energy power generation.
No Action – alternative coal markets		X	Consider any reasonable alternatives for exporting Kayenta Mine coal.

Table 1-13 Public Scoping Resource Issues Addressed in the EIS

Affected Facility			Impact Issue	EIS Section Where Addressed
NGS	**Proposed KMC**	**WTS/STS**		
Air Quality				
X	X		Impacts of criteria and hazardous air pollutants from power plant stack emissions, other combustion sources, and fugitive dust on local and regional air quality and consequent (indirect) impacts on ecological systems and human communities.	1.7.1.3.1, 3.1.1.2, 3.1.4.2.1, 3.1.4.3.1.1
X			Impacts of power plant stack emissions on formation of regional haze and the indirect effects on air quality related values (visibility in Class I and Class II areas).	3.1.4.3.1, 3.1.4.3.5
Climate Change				
X	X		Impacts of project greenhouse gas emissions on local and regional climate and air quality, and the consequent impacts on surface water and groundwater resources, ecological systems, and human land uses.	3.2.4.1
Landforms and Geology, Mineral Resources, Paleontology				
X	X		Impacts to scientifically valuable paleontological resources located in project areas proposed for surface disturbance.	3.5.4.5.2
	X		Impacts on geology and mineral resources from mining activities.	3.3.4.3.2, 3.4.4.3.2
Water Resources				
X			Impacts on water quality from coal ash constituent migration into aquifers underlying the NGS.	3.7.4.2.1.1
	X		Impacts of N-Aquifer drawdown by mine water supply wells and other groundwater withdrawals, on local and regional spring and stream flows; and water quality in relation to human and wildlife use areas.	3.7.4.2.2.1
	X		Impacts of N-Aquifer drawdown by mine water supply wells and other groundwater withdrawals on subsidence and sinkhole creation.	3.3.4.3.2.2, 3.7.4.2.5.3
	X		Impacts of surface runoff sediment from mined areas on water quantity and quality in stormwater detention ponds and downstream drainages used for livestock and other human uses.	3.6.4.6.2.1, 3.7.4.2.2.6
	X		Alternative water supply options (other than the N-Aquifer) for dust suppression and other consumptive uses at the mine.	3.7.4.2.2.2
Biological Resources				
X	X	X	Impacts on quantity and quality of soils removed and stored during surface disturbance activities and the subsequent vegetation cover and diversity in revegetated areas used by wildlife. Impacts of non-	3.8.4.3.2.1, 3.9.4.1.2.1

Table 1-13 Public Scoping Resource Issues Addressed in the EIS

Affected Facility			Impact Issue	EIS Section Where Addressed
NGS	Proposed KMC	WTS/STS		
			native plant invasion into revegetated areas and natural communities.	
X	X	X	Impacts on the quantity and quality of wildlife habitat removed by disturbance of natural communities and on wildlife populations displaced by surface disturbance, human activity, and noise.	3.10.4.3.2.1
	X		Impacts to plant and animal individuals and populations (including special status species) from decreased flows from springs and streams affected by mine groundwater drawdown.	3.10.4.3.2.2
X	X		Impacts on aquatic and terrestrial species (including special status species) reproduction and growth from exposure to trace metals and other pollutants through inhalation and food chain bio-concentration.	3.10.4.3.2.3, 3.12.4.3.1.1, 3.13.4.4.1.1
Land Use, Transportation, Grazing, Residential Uses, Recreation, Visual Resources				
	X		Impacts of relocations on local residents displaced by expanded mining and compensation for relocation.	3.14.4.3.2.1
	X		Impacts of active mine activities (clearing, blasting, coal hauling, dewatering) on local land uses (livestock grazing and water sources, human water sources, traditional plant gathering).	3.14.4.3.2.1
X	X		Impacts of particulate emissions and other constituents of regional haze on viewsheds in the vicinity of the project.	3.14.4.3.1.2
	X		Impacts of airport lighting on night skies observed from Black Mesa.	1.7.2.1.6, 3.10.4.3.1.2
Public Health and Safety				
	X		Impacts on human health from identified potential hazards from industrial activities (electromagnetic radiation, power pole preservatives, dust suppressants, coal seam fires, periodic mine overburden blasting). Impacts on human health from burning coal for indoor heating.	3.15.4.3.2.2, 3.15.4.3.3.2
X	X		Impacts on human health, growth, and reproduction from exposure to emitted trace metals and other pollutants from inhalation and food chain bio-concentration. Sources of exposure include soil, water, wild and garden vegetation, wild game, and livestock.	3.16.5.3.1, 3.16.5.3.2
Cultural Resources, Community Values, and Traditional Knowledge				
X	X	X	Impacts of construction activities and mining on cultural resource sites, artifacts, and human burials.	3.17.4.3.2
	X		Impacts to the traditional cultural values and sacred sites (including springs) that are associated with the Black Mesa and how these values will be addressed	3.17.3.3.4

Table 1-13 Public Scoping Resource Issues Addressed in the EIS

Affected Facility			Impact Issue	EIS Section Where Addressed
NGS	Proposed KMC	WTS/STS		
			in mining and reclamation.	
	X		Impacts to tribal members living traditional life styles who must engage with PWCC and federal agencies on land use (home sites, grazing, water supplies, traditional use plant gathering) and reclamation decisions.	3.17.3.4
X	X		Impacts of project activities in relation to the Fundamental Laws of the Diné.	3.18.3.1.6.2, 3.18.3.1.6.3
Social and Economic Conditions				
X	X		Impacts on PWCC and NGS owner revenues and costs from current and future operations based on Kayenta Mine coal volume and production costs, and the production costs of coal-fired electrical generation at the NGS.	3.18.4.3.1.2, 3.18.4.3.2.2
X	X		Impacts of the current and future financial contributions of coal mining and electrical generation (royalties permit and lease fees, payments to communities) to the Navajo Nation and Hopi Tribe.	3.18.4.3.6.3
X	X		Impacts of Tribal member hiring practices on current and future power plant and mine hiring of Navajo and Hopi, and impacts of power plant and mine operations on regional employment and wages.	3.18.4.3.6.1
X	X		Impacts of ongoing demographic, economic, attitudes, and social organization trends in Navajo and Hopi populations, including trends in local crime and law enforcement capability, and trends in community physical and mental health. Impacts to the social fabric and values that provide incentives for younger tribal members to remain on the Reservation.	3.18.4.3.6.2
X	X		Impacts of current and future costs of power required for CAP pumps. Economic impacts if there are reductions in surplus revenues for the Development fund, and funding for Indian water settlements.	3.18.4.3.6.5
X			Impacts of the social cost of carbon in accordance with federal agency guidance.	3.2.4.2.4
X			Impacts of trading power plant pollution reduction credits by Tribes or power plant owners.	1.8.1

Table 1-13 Public Scoping Resource Issues Addressed in the EIS

Affected Facility				
NGS	Proposed KMC	WTS/STS	Impact Issue	EIS Section Where Addressed
Environmental Justice				
X	X		Impacts expressed as disproportionately high adverse human health and environmental effects of federal programs, policies and activities on minority populations. Concerns on this topic include: extraction of groundwater for industrial uses rather than local community uses; disproportionate environmental and social impacts for tribal members living in the vicinity of the Kayenta Mine who desire to live a traditional life style, or believe that economic benefits are not fairly shared; disproportionately high economic benefits to the CAP tribes that receive power from the NGS compared to tribal members living where mining and electrical generation occur.	3.18.4.3.1, 3.18.4.3.2, 3.19.4.3.1, 3.19.4.3.2

1.13 References

Council on Environmental Quality (CEQ). 2002. Memorandum for the Heads of Federal Agencies; State and Local Governmental Entities; State Governors; and Tribal Leaders. From James Connaughton. Co-operating Agencies in Implementing the Procedural Requirements of the National Environmental Policy Act. January and February 2002.

Council on Environmental Quality (CEQ). 1971. Council on Environmental Quality, Guidelines, Section 10(b), 36 Federal Register 7724-29 (1971) (Revised Guidelines).

Holt, R. G. 2010. United States Department of the Interior, Office of Hearings and Appeals. Order DV 2009-1-PR thru DV 2009-8-PR. Nutumya's NEPA Motion Granted (Docket No. DV 2009-4-PR). Salt Lake City. Internet website: http://www.wrcc.osmre.gov/initiatives/blackMesaEIS/AdministrativeLawJudgeDecision.pdf . Accessed February 7, 2015.

Joint Federal Agency (JFA) Statement. 2013. Joint Federal Agency Statement Regarding Navajo Generating Station. January 4, 2013.

National Park Service. 2005. Environmental Assessment for the Navajo Generating Station Water Intake Project. Page, Arizona. March 2005.

National Renewable Energy Laboratory (NREL). 2012a. Navajo Generating Station and Air Visibility Regulations: Alternatives and Impacts. Phase I Report by D. J. Hurlbut, S. Haase, G. Brinkman, K. Funk, R. Gelman, E. Lantz, C. Larney, D. Peterson, and C. Worley. Technical Report NREL/TP-6A20-53024. Contract No. DE-AC36-08G0283-08. Revised March 2012.

National Renewable Energy Laboratory (NREL). 2012b. Navajo Generating Station and Clean-Energy Alternatives: Options for Renewables. Phase II Report by D. J. Hurlbut, S. Haase, C. S. Turchi, and K. Burman. Technical Report NREL/TP-6A20-54706. Contract No. DE-AC36-08G028308. June 2012.

Office of Surface Mining Reclamation and Enforcement (OSMRE). 2011. Environmental Assessment: Kayenta Mine Permit (AZ-0001D) Renewal (Navajo County, Arizona). U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement (Western Region). August 2011. 185 pp + appendices.

Office of Surface Mining Reclamation and Enforcement (OSMRE). 2008. Black Mesa Project Final Environmental Impact Statement. U.S. Department of the Interior FES 08-49, OSM-EIS-33. November 2008.

Office of Surface Mining Reclamation and Enforcement (OSMRE). 1990. Proposed Permit Application, Black Mesa-Kayenta Mine, Navajo and Hopi Indian Reservations, Arizona. Final Environmental Impact Statement OSM-EIS-25. Denver, Colorado.

Peabody Western Coal Company (PWCC). 2012 et seq. Kayenta Complex Permanent Program Permit AZ-0001E Life-of-Mine Plan Revision. Submitted to OSMRE May 1, 2012. Last updated March 27, 2015.

Salt River Project Agricultural Improvement and Power District (SRP). 2012. Personal communication from J. F. Sullivan (SRP) and The Honorable K. Salazar, Secretary of the Interior, RE: Navajo Project NEPA and ESA Compliance. July 20, 2012.

U.S. Bureau of Reclamation (Reclamation). 1972a. Final Environmental Statement Proposed Central Arizona Project. FES-72-35. Boulder City, Nevada. September.

U.S. Bureau of Reclamation (Reclamation). 1972b. Final Environmental Statement Navajo Project. FES 72-1. Boulder City, Nevada. February.

U.S. Department of the Interior. 2012. Personal communication from D. J. Hayes, Deputy Secretary of the Interior, and J. Sullivan, Salt River Project Agricultural Improvement and Power District (SRP). Regarding SRP Letter dated July 20, 2012.

Chapter 2.0

Proposed Action and Alternatives

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Acronyms and Abbreviations

1969 Lease	Navajo Project Indenture of Lease
BART	Best Available Retrofit Technology
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BM&LP Railroad	Black Mesa & Lake Powell Railroad
BO	Biological Opinion
CAP	Central Arizona Project
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO_2	carbon dioxide
Co-tenants	Salt River Project, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company
Development Fund	Lower Colorado River Basin Development Fund
EIS	Environmental Impact Statement
ERA	Ecological Risk Assessment
ESA	Endangered Species Act of 1973
HHRA	Human Health Risk Assessment
km	kilometer
KMC	Kayenta Mine Complex
kV	kilovolt
kW	kilowatt
LOM	Life-of-Mine
MW	megawatt
N-Aquifer	Navajo Aquifer
NEPA	National Environmental Policy Act of 1969, as amended
NGS	Navajo Generating Station
NGS Participants	U.S. (Reclamation), Salt River Project, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company
NHPA	National Historic Preservation Act
NNEPA	Navajo Nation Environmental Protection Agency
NO_2	nitrogen dioxide
NO_X	nitrogen oxide
OSMRE	Office of Surface Mining Reclamation and Enforcement
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter of 10 microns or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 microns or less
PFR	Partial Federal Replacement
PWCC	Peabody Western Coal Company
Reclamation	U.S. Bureau of Reclamation
ROW	Right-of-way

SO_2	sulfur dioxide
SRP	Salt River Project Agricultural Improvement and Power District
STS	Southern Transmission System
tpy	tpy
U.S.	United States
USEPA	U.S. Environmental Protection Agency
WTS	Western Transmission System

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2.0 Proposed Action and Alternatives

2.1 Introduction

The purpose of this chapter is to identify and describe the alternatives that are evaluated in detail in Chapter 3.0 of the Environmental Impact Statement (EIS). The Proposed Action, referred to as the Navajo Generating Station (NGS)-Kayenta Mine Complex (KMC) Project, and three action alternatives are described in detail. A No Action Alternative also is described, which represents what is reasonably expected to occur if federal approvals, that are necessary to implement the Proposed Action, are not granted. These descriptions form the basis for comparing the environmental impacts, anticipated to occur with implementation of each of the alternatives, against one another in Chapter 3.0.

In accordance with the National Environmental Policy Act of 1969, as amended (NEPA), the EIS must "[r]igorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated" (40 Code of Federal Regulations [CFR] Part 1502.14(a)). It also must consider reasonable alternatives that are not within the jurisdiction of the lead agency (40 CFR Part 1502.14(c)). NEPA regulations specifically direct the federal agency to "[s]tudy, develop, and describe alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources" (40 CFR Part 1507.2(d)).

As outlined in Section 1.5.1, the purpose and need for the Proposed Action is:

> To secure, after 2019, a continuously available and reliable source of power and energy to operate the CAP pumps, which would be competitively priced with NGS and could be sold as surplus power to generate revenues for deposit to the Development Fund, and to satisfy the purposes of the Arizona Water Settlements Act

This purpose and need statement was revised from the statement in the Notice of Intent published in the *Federal Register* on May 16, 2014 (79 Federal Register 28546) announcing the United States (U.S.) Bureau of Reclamation's (Reclamation's) intent to prepare an EIS for the NGS- KMC Project. The refinement to include the need for a competitively priced source of power and energy as part of the purpose and need was made as a result of comments received during the scoping process.

In this chapter, Section 2.2 provides a summary of the steps taken to explore and evaluate potential reasonable alternatives, including alternatives not within Reclamation's jurisdiction. The process by which potential alternatives were considered, dismissed from further evaluation, or carried forward in the EIS is described. A more detailed explanation of the process through which alternatives were considered and eliminated from further evaluation in the EIS is provided in **Appendix 2A**. Section 2.2.1 addresses potential alternative energy sources to coal-fired generation, which could replace the federal share of power generated by the NGS. Section 2.2.2 provides a short explanation as to why alternatives to existing NGS- and Kayenta Mine-related infrastructure components were not considered to be reasonable. Section 2.2.3 focuses on the process by which alternatives to the federal share of NGS power and energy were considered.

Section 2.3 provides a description of the alternatives evaluated in detail in Chapter 3.0: the Proposed Action (Section 2.3.1); three Partial Federal Replacement (PFR) alternatives (Section 2.3.2); and the No Action Alternative (Section 2.3.3). All the facilities included in the Proposed Action are presently in operation and are anticipated to continue operations through 2019. To provide context and background for descriptions of the Proposed Action and alternatives, ongoing NGS and Kayenta Mine operations (through the end of the lease term on December 22, 2019) are described in Section 1.7, Historical

Operations of NGS and Kayenta Mine. In Chapters 2.0 and 3.0, activities associated with the Proposed Action and alternatives during the period from 2020 through 2044, plus decommissioning, are described.

2.2 Formulation of Alternatives and Alternatives Eliminated from Further Consideration

2.2.1 Power and Generation Alternatives

To ensure full consideration of all reasonable alternatives that could meet the purpose and need for the Proposed Action, Reclamation investigated the practicability of replacing the NGS in its entirety with power generation facilities that would emit less carbon than coal ("lower-emitting sources"). None were carried forward for further analysis. **Table 2-1** identifies the facilities evaluated, and the basis for each alternative facility's elimination from further consideration. A full replacement alternative that utilizes renewable sources (wind, solar) was not considered in detail because the continuously available and reliable criteria included in the Purpose and Need could not be met without substantial backup power (e.g., natural gas combined cycle generation). This combination of generation sources would not be competitive with NGS (Section 2.2.3.1, Total Replacement).

Table 2-1 Alternative Power and Generation Sources Considered for Full Replacement

Source	Rationale For Dismissal
Retrofit NGS to Natural Gas	Background. This alternative would substitute natural gas for coal as a fuel source at NGS, requiring a retrofit of the boilers that generate steam, and providing a natural gas supply, which does not currently exist. The existing boilers are incompatible with natural gas. A retrofit would be difficult to accomplish on-site while keeping the NGS operational during the interim. Moreover, natural gas supplies do not exist in the vicinity of NGS; a 20-inch gas transmission line approximately 135 miles in length would need to be constructed at an estimated cost of $3.1 million per mile (Interstate Natural Gas Association of America 2014). Retrofitting the NGS to a natural gas facility is not carried forward in the EIS because the capital and operating costs would significantly reduce opportunities to generate and market surplus power thus not meeting the purpose and need. In addition, non-federal NGS Participants have indicated that retrofitting is not economically justifiable compared to building a new gas-fired generating plant in a different location, which is the equivalent of the No Action Alternative.
Hydropower/pumped storage	Background. This alternative would substitute electricity generated by hydropower units for electricity generated by coal at NGS. Central Arizona Water Conservation District currently holds a contractual allocation to 161.6 MW and 182,235 MWh of hydropower capacity from Hoover Dam, which is used to provide ramping, reserves, and regulation power of the CAP. All current supplies of hydropower from Hoover Dam are fully appropriated. Current Hoover Dam contracts expire in September 2017. Central Arizona Water Conservation District's new post 2017 contract share of Hoover Dam energy will be reduced to 171,422.3 MWh, while its capacity allocation will remain unchanged.[1] The CAP system includes pumped storage hydropower generating capacity at Lake Pleasant, where water is stored in the fall, winter, and spring when power rates are

[1] Declining water levels in Lake Mead due to ongoing drought have already reduced Central Arizona Water Conservation District's delivered capacity from Hoover Dam by 25 percent, and Lake Mead water levels are projected to continue to decline over the near term, resulting in further capacity and energy reductions.

Table 2-1 Alternative Power and Generation Sources Considered for Full Replacement

Source	Rationale For Dismissal
	lower, and then released during summer when the Lake Pleasant power plant is able to generate hydropower during periods of peak power demand. This process does not result in any net power generation increase. No other pumped storage opportunities exist on the CAP system that could provide sufficient quantities of power to operate all or even a portion of the CAP pumps. Hydropower/pumped storage alternatives are not carried forward in the EIS because this technology does not meet the purpose and need; it is not technically feasible given the current available hydropower generating capacity.
Nuclear	Background. This alternative would substitute electricity generated from a regional nuclear power plant for electricity generated by coal at NGS. There is limited power available from the existing Palo Verde Nuclear Generating Station near Phoenix following plans by Public Service of New Mexico to use power from Palo Verde to replace capacity being lost at the San Juan Generating Station. Plans to build a fourth unit have not progressed; therefore additional capacity will not be available in the near future. Nuclear generation is not carried forward in the EIS because of the current limitations for available nuclear generating capacity and time required to bring additional capacity on-line.
Biomass	Background. This alternative would substitute electricity, generated from a biomass fuel (most likely solid waste, or biomass crops) burned at a separate generation facility, for electricity generated by coal at NGS. Current biomass generation technology generally is suited to a partial replacement alternative. Wood, agricultural, manufacturing waste and diverted municipal solid waste are the most common fuels for biomass generation. Transportation costs, cooling water needs, air quality concerns, and relatively high cost of produced energy result in biomass not being economically competitive even though municipal solid waste volumes in the Phoenix metropolitan area could be adequate to support a facility (National Renewable Energy Laboratory 2012). Moreover, legal arrangements to access waste streams and siting challenges raise concerns of the ability to be operational by 2025.[2] Biomass is not carried forward in the EIS because it does not meet the purpose and need and is not considered technically feasible given the time to bring a biomass unit on-line.
Conservation	Background. This alternative would include electrical use reduction measures that would be equivalent to the electricity generated by coal at NGS. Conservation is a demand-side management approach. The year-round industrial pumping loads associated with CAP offer limited opportunity for conservation beyond that which Central Arizona Water Conservation District already achieves through operational optimization. Complete elimination of pumping demand is not feasible and the prospective gains in efficiency do not support the capital investment required to replace existing pumps with different technology. Conservation is not carried forward in the EIS because this option does not meet the purpose and need and is not technically feasible.

[2] The year 2025 was considered to be an adequate timeframe for construction of a new project subsequent to an expected Record of Decision.

2.2.2 Existing Project Component Alternatives

This analysis also considered alternatives that could potentially replace or modify major components associated with the NGS and proposed KMC and reduce environmental impacts. All of the major infrastructure components associated with the NGS and proposed KMC are in place and operational, representing substantial in-place capital investment that has been largely amortized. In general, the economic costs and lack of any technical or environmental advantage associated with replacing these components resulted in no alternatives being carried forward. **Table 2-2** identifies the rationale for eliminating component alternatives from further consideration.

Table 2-2 Alternatives Considered for the Major Proposed Action Components

Component	Rationale For Dismissal
Transmission Systems and Communications Sites	Description. This alternative would provide a different or modified transmission system to deliver electricity from NGS to CAP. Present day transmission system design and construction techniques do not offer operation, maintenance, or environmental benefits to offset the additional construction, costs, land disturbance, and visual impacts that would result from decommissioning and replacement of the existing facilities. Communication sites currently are located on the most favorable terrain for communication purposes. Many of the NGS communication sites are co-located with communication sites that are owned and operated by others and thus relocating the NGS-related facilities could result in additional communication sites across the landscape. Substantive issues or complaints have not been raised regarding existing sites and overriding benefits from relocating sites to other locations have not been identified. No replacement transmission systems or communication facilities alternatives are carried forward in the EIS because replacement of the transmission systems or communication facilities do not offer lower impacts to the environment over the Proposed Action.
Black Mesa & Lake Powell (BM&LP) Railroad	Description. This alternative would provide a different or modified coal delivery system from the Proposed Kayenta Mine Complex to NGS. Contemporary railroad design and construction do not offer sufficient advantages over the existing facility with respect to siting, efficiency, or long-term environmental effects, which would warrant replacement of the historical operation. Replacement of electric locomotives with diesel would result in higher cost of operation (diesel fuel, fuel delivery, fuel storage, and fueling system) and incur costs to remove the existing railway system. The existing system is tied into the NGS power supply. Use of diesel-fueled locomotives would increase emissions along the right-of-way (ROW) from the historical operations. Replacing rail haul with truck haul would not be economically efficient. Truck haul would require a fleet of more than 100 semi-trucks and several hundred drivers, fleet maintenance and administrative staff. Coal transportation costs would be substantially higher as a result of the capital investment in tractors and trailers, outlays for fuel, tires and other parts and supplies, and staff expense. It also would result in substantially more traffic on highways (the existing rail is in a separate ROW). No coal transport alternatives to the BM&LP Railroad are carried forward in the EIS because replacement of the existing rail system does not offer lower impacts to the environment in terms of air quality and public safety over the Proposed Action.
New Coal Supply/Mine	Description. This alternative would provide a new coal source for use by NGS. Providing coal from a coal supply other than Peabody Western Coal Company's (PWCC's) Kayenta Mine is not feasible. There are no other active coal mines with

Table 2-2 Alternatives Considered for the Major Proposed Action Components

Component	Rationale For Dismissal
	suitable coal within a reasonable distance to transport the coal. Nor is there a transportation network available to transport the coal, in a safe and more environmentally sound manner than current practice, from more distant sources in New Mexico or Colorado. It would not be feasible to identify and develop a new coal source in a timely manner that meets the NGS plant operational specifications, even if one was available. The environmental impacts from developing a new mine would likely be equal to or more substantial than those already resulting from current operations at the Kayenta Mine. Nor is it reasonable to anticipate that an entity would invest in developing a new coal source for a generation plant that is intended to cease operation in 2044. No coal supply alternatives are carried forward in the EIS because replacement of the existing mining operation with an alternative coal source does not meet the OSMRE Purpose and Need does not offer lower impacts to the environment over the Proposed Action; and may not be technically or economically feasible within the timing constraints.
Limited incorporation of former Black Mesa Mine support facilities, that are used for mining operations, into the Kayenta Mine permit area	Description. Instead of incorporating the entire former Black Mesa Mine lease area, this alternative would include the Kayenta Mine plus the 566 acres associated with support facilities that are located in the former Black Mesa Mine area that are used by the Kayenta Mine operations. This alternative has the same environmental impacts as the Proposed Action because the mine plan would not change. This alternative would not result in less environmental impacts than the Proposed Action. Mining and other land-disturbing activities anywhere on the mine leasehold would continue to be subject to review pursuant to NEPA, whether incorporated into the proposed KMC under this Proposed Action or evaluated under a separate NEPA process. However, this alternative would not allow for timely minor repairs to address operation, maintenance or other unplanned unsatisfactory environmental or safety conditions that occur within the entire mine leasehold, or arise from weather-related or other natural events. Required access and response action approvals for minor land-disturbing activities located outside the permanent permit boundary require time-consuming administrative steps that are not required for similar actions within the permanent permit boundary. Thus, this alternative would allow potentially unsafe and unsatisfactory environmental conditions to persist and be left unattended for extended periods of time. This alternative was eliminated from further evaluation.
No mining on Hopi Tribe surface (J-21W) to protect cultural resources.	Description. No surface disturbing activities would be allowed on J-21W to insure protection of cultural resources. Coal that would otherwise be mined on J-21W would be mined within other coal resource areas on the KMC. This alternative could be implemented by changing the PWCC Life of Mine Plan currently under review by OSMRE. Approximately 46 million tons of coal would be mined from J-21W from 2024 through 2044 (Table 2-6), which represents slightly less than ½ the total coal that would be mined from all three joint coal resource areas (J-19, J-21, and J-21W) (Figure 2-1). While not quantifiable, it is likely that Hopi would receive lower shared revenue if J-21W were not mined, and new or expanded mining was relocated onto Navajo or other Joint Use surface. Cultural resources potentially present on J-21W are currently under investigation, and more specific information will be available within the time frame of this EIS. Through implementation of the KMC Programmatic Agreement and subsequent treatment plans, there would be opportunities to avoid cultural resources while allowing surface coal mining to occur. In summary, a mining prohibition on J-21W could potentially reduce the long-term economic benefits to the Hopi Tribe, and it would be premature to limit future development before cultural resource values are fully disclosed, and considered by the members of the Hopi Tribe. Because of these uncertainties and

Table 2-2 Alternatives Considered for the Major Proposed Action Components

Component	Rationale For Dismissal
	risks, this alternative was not further developed for analysis.
Water Supply/Kayenta Mine	Description. This alternative would substitute D-Aquifer groundwater for N-Aquifer groundwater for Kayenta Mine industrial and potable uses. Based on groundwater modeling results and other analyses, the D-Aquifer underlying the proposed KMC was determined to be of insufficient quantity and quality to replace the total water withdrawn from the N-Aquifer for mine and potable water use. In addition, economic considerations preclude installation of necessary infrastructure to pump water from the D-Aquifer for dust suppression only. Further justification for this conclusion was previously provided in Office of Surface Mining Reclamation and Enforcement (OSMRE) environmental reviews (OSMRE 2011, 2008), and also in the water resources section (see Section 3.7.4.2 of this EIS). No mine water supply alternatives are carried forward in the EIS because replacement of the water source is not economically feasible and would not provide an adequate supply.
Cooling water/NGS	Description. This alternative would substitute another cooling water source for surface water from Lake Powell There are no other sources of surface water available for use at NGS. Pumping groundwater from the N-Aquifer, while possible, is not considered to be reasonable because of the great depth to groundwater at this location, There are no existing water supply wells developed in this source and NGS annual water requirements (up to 40,000 acre feet per year) would exceed the sustainable aquifer yield. Use of Lake Powell water would result in withdrawal of relatively small water volumes as compared to the total capacity of this large reservoir, and all pumping facilities and pipelines are already in place. No NGS cooling water alternatives are carried forward in the EIS because a different water source is not economically feasible and use of the N-Aquifer would be unsustainable as compared to Lake Powell, which is a renewable source.
Clean Coal Technology (Coal Gasification and Carbon Sequestration)	Description. Clean coal technologies are centered around pre-combustion controls (creation of synfuels, such as hydrogen), and post-combustion controls (carbon dioxide sequestration) that involve underground injection, or carbon dioxide capture and conversion to a solid carbonate http://energy.gov/fe/science-innovation/clean-coal-research, http://saskpowerccs.com/ccs-projects/boundary-dam-carbon-capture-project/. Pre-combustion controls would require construction of a separate coal synfuels facility. The resulting fuels (gas, liquids) are not compatible with NGS coal combustion operations, which would require a major retrofit (see Table 2-1 Retrofit to Natural Gas). Demonstration synfuel projects have been developed, but commercial scale projects such as NextGen 2.0 requiring federal funding support have been discontinued. An investment in pre-combustion coal technology would not meet the purpose and need because of the immaturity of the technology, and construction and operation costs that are not competitive with those of NGS. Carbon dioxide capture and storage is a developing technology that has not been applied at a scale comparable to the output from NGS. The 2,475 MW W.A. Parish Plant in Texas is being retrofitted to capture the carbon dioxide from a 240 MW unit. Approximately 90 percent of the emitted carbon dioxide is captured by an amine absorption process, and then injected into a nearby oil field for enhanced oil recovery. https://www.globalccsinstitute.com/projects/petra-nova-carbon-capture-project (Global Carbon Capture 2016). The W.A. Parish project is being partially supported by U.S. DOE grants, with a budget in excess of $1 billion. The enhanced

Table 2-2 Alternatives Considered for the Major Proposed Action Components

Component	Rationale For Dismissal
	oil recovery benefits associated with the W.A. Parish plant could not be replicated at NGS. The nearest enhanced oil recovery area to NGS would be in southeastern Utah, which would require a new pipeline to the vicinity of Aneth, Utah. Carbon sequestration would not meet the purpose and need because of very high capital and operation costs that are not competitive with NGS operations.
Retire two NGS units, and operate one.	Description. Two units at NGS would be taken out of service, and one would continue to operate after 2019. Decommissioning two units would result in a two-thirds reduction in power production, which would exceed the federal NGS share, and would not allow the other NGS participants to meet their obligations for power delivery, or to recover operating costs. This alternative would not meet the Reclamation purpose and need, and would infringe on the rights of the other participants.

2.2.3 Federal Replacement Power Alternatives

The Notice of Intent indicated that two alternatives were being considered for evaluation in the EIS: a PFR alternative and a total federal replacement alternative. The Notice of Intent also indicated that additional alternatives could be added for consideration following scoping and in response to Reclamation's further consideration of the purpose and need, of which none were identified.

Public interest expressed during scoping demonstrated strong support for Reclamation reducing its share of carbon dioxide emissions associated with supplying power to the CAP. Numerous comments received during scoping supported the study of potential EIS alternatives focused on replacing all or a portion of the federal share of power from NGS with power from sources that would reduce atmospheric emissions over those resulting from implementation of the Proposed Action. A majority of the scoping comments received regarding alternatives to the Proposed Action advocated use of renewable energy sources.

Incorporating public input received during scoping, Reclamation centered the alternatives development process on examining the replacement of federal share in NGS, total or in part, with lower-emitting sources. Reclamation adopted a stepwise approach that included research, assessment of technical viability, economic analysis and market factors, and alternatives formulation based on information from previous steps in the process. The remainder of this section describes the approach, outcomes, and ultimately the action alternatives developed for inclusion in the EIS.

2.2.3.1 Inventory of Project Concepts and Proposals

The first step in the alternatives development process was research. Working in conjunction with the National Renewable Energy Laboratory and AECOM, Reclamation developed an inventory of lower-emitting energy generation options (i.e., projects and proposals) identified as being under consideration for development in Arizona and nearby areas of surrounding states. The extensive inventory incorporated options from the following sources:

- Input from public scoping;
- The Bureau of Land Management's (BLM's) Solar Energy Plan and programmatic EIS for six southwestern states (BLM 2012);
- Print media and online resources including renewable energy trade information releases and announcements; and

- National Renewable Energy Laboratory's ongoing research on renewable energy, for example, the U.S. Department of Energy's SunShot Vision Study (U.S. Department of Energy 2012).

The inventory was comprised of 169 options as listed in **Appendix 2A, Attachment 2A-1.** The name, technology type, developer, estimated generation in megawatts (MW), and potential interconnection points for delivery to the CAP system are provided. Technology types identified in the inventory were solar, wind, hydropower, natural gas, biomass, nuclear, geothermal, and combinations of these technologies. This research established a foundation to conduct a technical analysis.

2.2.3.2 Technical Screening Criteria

The next step in the alternatives development process was to assess the technical viability of potential replacement options identified through the research phase. Technical screening criteria were established that all potential alternatives would need to meet to be considered reasonable alternatives for further analysis. In general, the screening criteria addressed essential technical requirements as established in the purpose and need, and practical implementation parameters such as timing and sizing. Those requirements include:

- Connecting to and optimizing the existing transmission system and infrastructure that deliver power to the CAP;
- Commercially proven technology, as demonstrated by at least one operating commercial scale facility in the U.S.;
- Providing competitively priced, reliable power on a continuous basis;
- Lower atmospheric emissions than NGS;
- Implementation by January 2025, which was considered an adequate timeframe following an expected Record of Decision to complete solicitation, procurement, authorization, permitting, construction, and amortization of the capital investment for a new project; and
- Sizing parameters based on federal share characteristics and operational constraints at NGS.

Table 2-3 depicts the screening criteria, thresholds or measurement units used for each criterion, and the basis or rationale for its inclusion in the technical assessment process.

Table 2-3 Technical Screening Criteria

Screening Level/Criteria	Thresholds or Measurement Units	Basis/Rationale for Inclusion
Level 1 – Technology and Consistency with EIS Purpose and Need		
1A. Capability to deliver electrical energy to CAP; to be competitively priced relative to NGS; and to facilitate the marketing of surplus power	Must be able to connect to existing transmission systems that currently deliver power to the CAP. Must optimize available infrastructure (capacity, transmission rights, and substations). Must demonstrate capital and operational costs similar to those of NGS.	Required by the EIS purpose and need.
1B. Commercially proven	Meets technical readiness thresholds established by National Renewable Energy Laboratory.	Must be existing proven, commercial–scale technology.

Table 2-3 Technical Screening Criteria

Screening Level/Criteria	Thresholds or Measurement Units	Basis/Rationale for Inclusion
1C. Reliable and continuously available	Must allow Central Arizona Water Conservation District to make water deliveries (via pumping) as scheduled.	Required by the EIS purpose and need.
1D. Lower-emitting source	Source must emit less atmospheric pollutants than would be emitted at NGS after Best Available Retrofit Technology (BART) compliance.	Based on the Notice of Intent, public scoping comments, and existing Technical Working Group federal commitments.
Level 2 – Timing		
2. Implementation timing	Must be implementable (operational) by 2025 (determined to be a reasonable period following the expected Record of Decision).	Adequate time to complete permitting and construction and allow for amortization of capital investment.
	Open market power purchases may be required between 2020 and 2025.	
Level 3 – Replacement of NGS Federal Share		
3A. Total replacement of NGS federal share	Must be compatible with Central Arizona Water Conservation District operations – minimum 3.0 terawatt hours to power CAP, with the ability to generate and market surplus energy.	The administration of the federal share in NGS falls under the jurisdiction and authority of the Department of the Interior.
3B. Partial replacement of NGS federal share	Capacity consistent with NGS operational curtailment range of the federal share: 25 MW to 309 MW.	The administration of the federal share in NGS falls under the jurisdiction and authority of the Department of the Interior.
	Must include own firming.[1]	NGS cannot be used as a firming source due to its operational constraints as baseload facility.
	Energy generated by the partial replacement is used to power CAP.	NGS continues to provide surplus energy.

[1] Firming refers to a secondary source of energy to compensate for the normal variability and irregularity of renewable energy generation (e.g., if part of a solar array is shaded by cloud cover) in order to assure delivery of a specific quantity of energy during a defined period of time.

Applying the screening criteria to the inventory resulted in 36 options passing all three levels; 14 were identified as total federal replacement options, and 22 were identified as PFR options. Technologies represented by the 36 options were solar, wind, natural gas, and a hybrid combining solar paired with natural gas. A detailed description of the screening process at all three levels is provided in **Appendix 2A**; summary results are provided in **Appendix 2A**, **Table 2A-4**.

The screening process demonstrated: 1) there are multiple opportunities for renewable and natural gas options over a wide geographic region that could provide NGS federal share replacement energy to the CAP; 2) the renewable energy market is still in a formative stage and is being driven more by meeting renewable portfolio objectives than by the potential profitability of new projects; 3) many recent renewable energy projects in the planning stage have been canceled because of a lack of commercial viability, and 4) the screening results provide insight into the generation technologies available and the scale of projects needed to meet NGS federal share replacement options.

Based on these insights and the uncertainties associated with the current and reasonably foreseeable energy market in Arizona, Reclamation concluded that it would be premature and impracticable to pursue specific options from the inventory as EIS alternatives because these proposed projects might not be optimal given future energy market uncertainties and potential changes in federal, tribal, and state energy policies and economic incentives. Reclamation also recognized that there are many combinations of technologies and project locations that could meet potential NGS federal share replacement needs. Reclamation anticipates that any arrangement to supply CAP power from a source other than the NGS would come about as a result of future procurement, competitive bidding and negotiation authorized by legislation, the specifics of which are unknown at this time. In conclusion, with respect to alternatives development, Reclamation considered the NEPA decisions that can be made in the near-term, versus decisions that are premature because of changing circumstances, speculation, or lack of essential information. While a range of NGS federal share replacement options can be established conceptually from available information within the time frame for the EIS, the actual project(s) that would provide replacement energy would be more concretely defined closer to implementation through the competitive process. The future NEPA evaluation of site-specific proposals, assuming power purchased through a power purchase agreement,[3] would allow a detailed and accurate review of effects on resources, economic benefits and costs. For these reasons, after the screening process was complete, Reclamation focused on the technology types identified through the screening rather than on specific projects, as described in the following sections.

2.2.3.3 Total Federal Replacement

The results of the screening process indicated that renewable (i.e., solar and wind) and natural gas technologies could supply enough energy for a replacement of the entire federal share of the NGS. Therefore, the next step in the alternatives development process was to further evaluate and differentiate between these suitable technologies; economic analysis based on the current and reasonably foreseeable energy market was recognized as the appropriate tool.

To address the “competitively priced” aspect of the project purpose and need, Reclamation enlisted the National Renewable Energy Laboratory as an experienced third party with internationally recognized expertise in the field, to conduct a series of three economic analyses. The first was a levelized cost of energy analysis, or total all-in price of generation per MW-hour (National Renewable Energy Laboratory 2015a). Levelized cost of energy provided a quantitative approach to assess which technology competed more favorably against another given reasonably foreseeable market conditions. The second analysis focused on prices at two particular locations – the Mead switchyard adjacent to Hoover Dam in southern Nevada, and the Palo Verde switchyard connected to the Palo Verde Nuclear Generating Station west of Phoenix, Arizona (National Renewable Energy Laboratory 2015b). These locations were selected for analysis because they are two of the most active wholesale power trading points in the Southwest with direct connection to CAP load and the California renewable energy market. This analysis also compared electricity prices at these two “trading hubs” to southern California contract prices to test whether the resale of power into the California market potentially could result in greater revenues. The third analysis provided projections of NGS future operating costs based on assumptions of future capital investments, lease and fuel costs (National Renewable Energy Laboratory 2015c).

The collective findings of these studies, and information from the National Renewable Energy Laboratory’s Annual Technology Baseline for 2015 (National Renewable Energy Laboratory 2015d), indicated that it would be difficult to recover capital costs for any new generation facility, whether selling into the Mead trading hub to southern California, or to one of the major utilities in Arizona. The National Renewable Energy Laboratory concluded a combination of abundant natural gas supplies and associated effects on natural gas prices and existing gas-fired generating capacity would likely keep spot

[3] A power purchase agreement is a contract between an electricity provider and customer through which the latter agrees to purchase energy and/or capacity under terms outlined in the contract (e.g., term, quality, and price).

market and short-term power purchase prices below the cost to justify construction of a new facility regardless of technology.

For example, the most cost-effective potential total federal replacement option in the inventory, a hybrid facility consisting of photovoltaic solar in conjunction with combined-cycle natural gas near McCullough substation in Boulder City, Nevada, yielded a levelized cost of energy range of $64 to $71 per MW-hour in 2020 (National Renewable Energy Laboratory 2015a). This is approximately 52 to 73 percent higher than the National Renewable Energy Laboratory's projected cost of production at the NGS in 2020 (i.e., $41 to $42 per MW-hour) (National Renewable Energy Laboratory 2015c). Based on CAP annual energy use of 2.7 terrawatt-hours, approximately $59 to $81 million would be added to the annual operating costs for Central Arizona Water Conservation District. The levelized cost of energy for the hybrid facility also exceeds the reasonably foreseeable market price of energy in 2020 at the Mead trading hub[4] by approximately 28 to 137 percent (National Renewable Energy Laboratory 2015b), substantially limiting the opportunities to generate revenues from the sale of surplus power. Sales of surplus power were projected to yield a net revenue of $21.9 million to the Lower Colorado River Basin Development Fund (Development Fund) in 2014, with net revenues of $22.7 million budgeted for 2015 (Central Arizona Water Conservation District 2013).

The above findings led Reclamation to conclude that a total federal replacement alternative did not meet two aspects of the federal purpose and need for the Proposed Action: (1) it was not competitively priced with NGS; and (2) there was no realistic expectation that surplus revenues could be provided for the Development Fund. Sufficient supplies of natural gas-generated power purchased on the spot market or through a power purchase agreement could potentially provide all of the power and energy necessary to operate CAP at a cost comparable to NGS; however, the availability of surplus – an important component of the purpose and need – under a total federal replacement alternative (i.e., no federal participation in NGS) is remote given current and reasonably foreseeable energy market conditions. Consequently, no total federal replacement alternative was carried forward for evaluation in the EIS.

2.2.3.4 Partial Federal Replacement

The economic analysis described in the previous section led Reclamation to determine that PFR alternatives could satisfy the purpose and need given certain key assumptions, and should be evaluated in the EIS. The final step in the alternatives development process was to formulate PFR alternatives for inclusion in the EIS. Similar to total federal replacement, the availability of surplus under a PFR alternative alone is remote given current and reasonably foreseeable market conditions; however, a PFR alternative paired with continued (but curtailed) federal participation in NGS could meet the federal purpose and need because surplus would continue to be provided by NGS. Therefore, the key assumption for any PFR alternative is NGS (including federal participation) continues beyond 2019. Several other assumptions were established to help formulate PFR alternatives for consideration in the EIS, including:

- NGS operates above minimum load normally during periods when the PFR alternative is not available, supplying power to the CAP and marketing the surplus;
- PFR alternatives replace a portion of the power used for CAP pumping from new or existing sources that are lower emitting than NGS;

[4] $30 to $50 per MW-hour.

- Curtailment[5] of the federal share at NGS would be paired with a power purchase agreement for a corresponding amount of power from the PFR alternative; and
- Any renewable source that is part of a PFR alternative must include its own firming[6] power to ensure reliability.

In addition, the public scoping process revealed three central considerations with respect to alternatives development: 1) seek to minimize energy costs to the CAP; 2) explore renewable energy technology as an economically proven option; and 3) consider tribal socioeconomic impacts.

To address these considerations, and utilizing information from the screening process and economic study, Reclamation defined three conceptual PFR alternatives for incorporation and comparative analysis in the EIS as follows:

(A) A power purchase agreement for power from existing non-coal generating sources (assumed to be natural gas) provided on a 24 hours per day, 7 days per week basis;

(B) A power purchase agreement for power from one or more existing renewable sources for a defined period, 14 hours per day, 7 days per week; and

(C) A power purchase agreement for power from a renewable energy facility (assumed to be photovoltaic solar) built on lands of a tribe affected by actions under this EIS for a defined period, 12 hours per day, 7 days per week.

From the screening process, Reclamation determined that it was not practicable to evaluate site-specific federal replacement options as alternatives in the EIS; therefore, these PFR alternatives are conceptual in nature using a power purchase agreement or request for proposal approach, focusing on technology rather than specific projects.[7] The power purchase agreement or request for proposal approach allows for the consideration and comparison of three lower-emitting generating sources with the Proposed Action and the No Action alternatives (Section 2.3.2).

For purposes of EIS analysis, the range of federal share curtailments at NGS under each PFR alternative was set between 100 MW and 250 MW. Currently, the curtailment range allowed by the NGS Operating Agreement for the federal share is a minimum of 25 MW and a maximum of 309 MW under certain operational and contractual conditions.[8] Reclamation selected 100 MW as the lower bound because it is approximately 30 percent of the maximum allowable federal share curtailment, and is scaled to allow informative environmental impact comparisons with the Proposed Action. Reclamation selected 250 MW as the upper bound because it represents the theoretical maximum federal share

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[5] Curtailment refers to voluntary or involuntary reductions in power output from what could otherwise be produced given available resources. In this case the output from NGS would be cut back or curtailed by an amount specified in a power purchase agreement to offset the amount of power being provided to the CAP by a PFR alternative.

[6] Firming refers to a secondary source of energy to compensate for the normal variability and irregularity of renewable energy generation (e.g., if part of a solar array is shaded by cloud cover) in order to assure delivery of a specific quantity of energy during a defined period of time. NGS cannot be used as a firming source due to its operational constraints as baseload facility.

[7] PFR alternatives developed for EIS purposes are not intended to foreclose any future potential PFR. For example, all 22 options from the inventory analyzed in the screening process that satisfied Criterion 3B (i.e., consistent with partial federal replacement) could be applicable to one or more PFR alternative as shown in **Appendix 2A, Attachment 2A, Table 4**

[8] Under existing arrangements with the NGS Co-tenants (SRP, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company), Reclamation is able to curtail 100 MW. Curtailments exceeding 100 MW would require additional technical, engineering, and cost studies to determine the impact on plant operations, efficiencies, and maintenance. It is anticipated that due to cost and generation implications, additional agreements among the NGS Co-tenants and Reclamation would be necessary prior to curtailments above 100 MW.

curtailment allowable based on potential future NGS operations with the installation of selective catalytic reduction (Salt River Project Agricultural Improvement and Power District [SRP] 2015).

Section 2.3.2 describes the PFR alternatives that are evaluated in detail in the EIS. Additional information on the screening process that was undertaken and reasons for not carrying other action alternatives forward for evaluation in the EIS is provided in **Appendix 2A**.

2.3 Alternatives Evaluated in Detail

This section provides a detailed description of what is reasonably expected to occur under each of the alternatives evaluated in detail in the EIS. The descriptions identify assumptions used in the evaluation of the anticipated environmental impacts described in Chapter 3.0.

2.3.1 Proposed Action

Under this alternative, NGS would be authorized to continue operating two or three units (under certain conditions) from December 23, 2019, through December 22, 2044. The authorization would require the Lease Amendment No. 1 (or a leasing agreement with the Navajo Nation having similar terms as the original NGS Lease and Lease Amendment No. 1) to be approved by the Secretary of the Interior and executed by the Navajo Nation, the NGS Co-tenants, and SRP on behalf of the U.S. NGS would continue to operate to provide electric power to customers, from 2020 through 2044, plus decommissioning. Historical (through 2019) NGS-related operation, maintenance, and repair/replacement practices would be expected to continue during this additional 25-year operational period, except as noted in Section 2.3.1.1.

The Secretary of the Interior also would approve the proposed KMC revised Life-of-Mine (LOM) plan and permit revision application, to identify the timing and sequencing of mining operations in certain coal resource areas to allow historical mining operations to continue uninterrupted at the proposed KMC, which would supply coal to the NGS throughout the 25-year operational period.

Decommissioning and reclamation activities that would occur for both NGS and mining operations after December 22, 2044, are described in this section. Descriptions of ongoing (historical) operations for NGS and the proposed KMC are provided in Section 1.7 of Chapter 1.0, to provide background for understanding the activities that would remain unchanged under the Proposed Action, and the activities that would cease, change, or be added during the period 2020 through 2044, plus decommissioning.

The Secretary of the Interior or designee also would be required to approve a number of other federal actions identified and described in this EIS, prior to implementing the Proposed Action. These actions are included in **Table 1-1** and described in **Appendix 1A**.

2.3.1.1 Navajo Generating Station

Certain adjustments would be made as appropriate to comply with changing environmental regulations, as well as new applicable regulations that become effective during the 2020-2044 time frame. The most significant of these regulations is the Federal Implementation Plan related to the Clean Air Act Regional Haze Rule, which was promulgated August 8, 2014, by the U.S. Environmental Protection Agency (USEPA). This Federal Implementation Plan, regarding site-specific BART provisions at NGS, requires that NGS achieve nitrogen oxide (NO_X) reductions within certain timeframes, while providing the NGS operator a choice among several operating scenarios to meet these reductions. Each of the operating scenarios identified in the Federal Implementation Plan would meet the requirements of a “better than BART” designation, under which NGS is required to operate to meet a 2009-2044 NO_X cap calculated based upon an annual emission rate of 0.055 pounds per million British thermal units (**Appendix 1B**).

The operating scenario ultimately implemented beginning January 2020 would be based, in large part, on the manner in which NV Energy divests of their ownership in NGS prior to December 23, 2019. As mentioned in Section 1.9.3, a decision by NV Energy on how and when it would exit from its ownership and participation in NGS generation, and if it sells its shares to a third-party, could affect the manner in which compliance with the Federal Implementation Plan is undertaken and its timing. As noted above, there are a number of scenarios that could occur; the main difference among them is whether or not NGS would need to generate power and energy in excess of the equivalent of two units operating at optimum capacities, to meet its Participant generation entitlements.

A number of combinations of ownership outcomes and emission reduction strategies could occur, which would determine the operation scenario ultimately implemented under the Proposed Action. For purposes of this EIS, emissions from the Proposed Action were estimated for a range of reasonably foreseeable operation scenarios that could be implemented.

On July 1, 2016, SRP and Los Angeles Department of Water and Power entered into an asset purchase agreement; however, it is unclear when and how NV Energy's divestiture would occur and the future operating scenario that would be implemented. It also is unclear if and when the Navajo Nation would exercise its option under Lease Amendment No. 1 (or a leasing agreement with the Navajo Nation having similar terms as the original NGS Lease and Lease Amendment No. 1) to become a Co-tenant of NGS with an entitlement of up to 170 MW. A number of combinations of ownership outcomes and emission reduction strategies could occur. The ownership outcomes with the highest and lowest resulting emissions were determined to be a 3-Unit Operation with a 2,250-MW capacity and a 2-Unit Operation with a 1,500-MW capacity, respectively. This range of emissions is used in Chapter 3.0 to evaluate the potential impacts that would result from operation of NGS under the Proposed Action. The emissions from the operation ultimately implemented under the Proposed Action, which would fall somewhere within that range, would depend upon the parameters under which the NV Energy divestiture occurs, and whether the Navajo Nation elects to participate in NGS.

Table 2-4 provides a comparison of 3-Unit Operation and 2-Unit Operation at NGS which establishes a foundation for analysis of the range of potential effects for the Proposed Action. Under both the 3-Unit Operation and 2-Unit Operation, 2.7 terrawatt-hours per year of energy would continue to be delivered to CAP.

Table 2-4 Characteristics of the 3-Unit Operation and 2-Unit Operation for the Proposed Action

Key Component	3-Unit Operation	2-Unit Operation
Coal delivery (tons per year [tpy])	8.1 million	5.5 million
Coal handling	Operate 3 units, conveyors, silos	Operate 2 units, conveyors, silos.
Coal storage	12 underground hoppers to receive coal; 30-day coal supply in storage.	Same as the 3-Unit Operation
Design power production (MW)	2,250	1,500
Heat output (million British thermal units per year) (based on actual operations)	194,373,190	129,581,127
Atmospheric Emissions (tons)		
Annual NO_X Emissions (tpy)		
Pre-selective catalytic reduction 0.21 pounds per million British thermal units	20,409	13,606
Post-selective catalytic reduction 0.07 pounds per million British thermal units	6,803	4,535

Table 2-4 Characteristics of the 3-Unit Operation and 2-Unit Operation for the Proposed Action

Key Component	3-Unit Operation	2-Unit Operation
Sulfuric Acid Mist Emissions (tpy)		
Pre-selective catalytic reduction	47.6	31.7
Post-selective catalytic reduction	389	259
Ammonia slip post-SCR	43.7	29.2
Greenhouse Gas (carbon dioxide [CO_2])emissions (tpy)	19,923,252	13,282,168
On-site vehicles	78 light duty vehicles	78 light duty vehicles
On-site heavy equipment	88 mobile source units	88 mobile units
Water allocation (acre-feet per year)[1]	40,000	40,000
Water treatment	NGS is a zero discharge facility, initial evaporation of process water occurs in cooling towers; wastewater is then discharged to evaporation ponds. All plant sewage is treated on-site, and discharged to evaporation ponds. Additional ponds may be constructed within the plant site to accommodate the 2020-2044 operating period; existing ponds may be closed and covered with soil.	Same as the 3-Unit Operation
Chemical/materials use (except ammonia)	See **Table 1-3** for a list of chemicals and volumes.	1/3 less volume than 3-Unit Operation.
Anhydrous ammonia use (tpy) (post-selective catalytic reduction emissions at 0.07 pounds/million British thermal units	17,500	10,500
Anhydrous ammonia deliveries (post-selective catalytic reduction emissions at 0.07 pounds/million British thermal units)	875 truck deliveries per year	535 truck deliveries per year
Mercury (Hg) sorbent use (gallons per year)	1,280,000	853,000
Coal combustion residuals (tpy)	1,440,000	978,000
Solid waste landfill	Inactive 2015	Same as the 3-Unit Operation
Asbestos landfill	Increased landfill capacity is not required to meet 20-year storage requirements; excess material may be transported to an approved facility off-site.	Increased landfill capacity is not required to meet 20-year storage and demolition requirements; excess material may be transported to an approved facility off-site.

Table 2-4 Characteristics of the 3-Unit Operation and 2-Unit Operation for the Proposed Action

Key Component	3-Unit Operation	2-Unit Operation
Coal combustion residual disposal site (765 acres, design capacity of 38 million cubic yards)	Existing disposal site capacity is sufficient; however, lateral extent would be expanded for operations through 2044.	Existing disposal site lateral extent and capacity sufficient for reduced operations through 2044.
Coal combustion residual sales	350,000 to 500,000 tpy; 775-800 trucks per month.	Sales and truck trips 1/3 less than the 3-Unit Operation.
Plant and railroad labor (routine operations) full time equivalents	550	431
Scheduled minor (4 weeks) and major (8 weeks) overhauls	3 years of minor annual overhauls followed by 3 years of major overhauls, to complete a 6-year cycle. Approximately 750 to 800 temporary workers on-site for each overhaul.	2 years of minor annual overhauls followed by 1 year with no overhaul and then 2 years of major annual overhauls followed by 1 year with no overhaul, to complete a 6-year cycle. Approximately 750 to 800 temporary workers on-site for each overhaul.
Community	Community efforts would include funding to benefit NGS Community Chapters, scholarship funds, and local benefit funds.	Community efforts would include funding to benefit NGS Community Chapters, scholarship funds, and local benefit funds.

[1] The projected range of annual NGS water use for the Proposed Action and alternatives is approximately 16,000 to 28,000 acre-feet as described in Section 3.7.4.

Note: The highest and lowest emissions scenarios are described in this table; due to future ownership decisions, the emission rate and other characteristics are expected to fall within the range of these high and low benchmarks.

Under either operation of the Proposed Action, the BM&LP Railroad would continue operations; however, the volume of coal delivered could decrease by about one-third for the 2-Unit Operation. Thus, instead of three trainloads of 8,000 tons of coal each day, the railroad may operate with a different schedule or capacity to meet NGS fuel demand. Fewer train trips or smaller trains hauling less coal would not substantially change maintenance requirements. Anticipated operation and maintenance operations of the BM&LP Railroad and other NGS associated facilities are described in detail in the NGS Operations and Maintenance Plan included in **Appendix 1B**.

2.3.1.1.1 Unit Shutdown Under the 2-Unit Operation

If one NGS unit was shut down after December 22, 2019, immediate actions for the shutdown unit would include draining water and other fluids used in normal operation. Any specific equipment that supports the shutdown unit would cease operation, including de-energizing the operating unit, and removing connections to plant-wide support systems such as coal feeding, unit pulverizers, and support operations for pollution control devices. Following shutdown of the unit, a determination would be made regarding key components, including:

- Maintain in shutdown mode pending completion of an agreement with a new NGS owner, such as the Navajo Nation;
- Sell components as used equipment;
- Maintain key equipment as spare parts;

- Salvage for scrap value;
- Abandon in place until spatial requirements are resolved for selective catalytic reduction installation;
- Abandon in place until final decommissioning;
- Repurpose for use in support of the remaining operating units; or
- Remove material and place in appropriate approved landfill.

Any mix of options, or variant among the above options could apply to any one of the pieces of equipment or support operations at the shutdown unit.

2.3.1.1.2 Decommissioning and Abandonment

Under the Proposed Action, the operating and support facilities at the plant site would be dismantled and demolished to ground level by the end of 2045, unless the Navajo Nation continues NGS operations beyond 2044. Decommissioning[9] of NGS and associated facilities may occur before 2044 consistent with the early termination provisions in the Lease Amendment and other NGS Project agreements. The overall decommissioning process is described in **Appendix 1B**.

The water supply facilities, and certain buildings and equipment would remain, in accordance with the 1969 Lease and Lease Amendment No. 1 (or a leasing agreement with the Navajo Nation having similar terms as the original NGS Lease and Lease Amendment No. 1). Specific facilities that would remain include the following:

- Lake Powell Pump station and both the suction lines between the lake and the pumps and the discharge lines from the pumps to the plant site;
- Administration Building;
- Warehouse;
- Machine Shop Building (currently part of the Service building);
- Visitor's Building (currently part of the Administration building);
- Automotive Maintenance Building (currently the Heavy Equipment building);
- Electric Shop;
- Welding Shop;
- Coal Crusher Building (Currently the Sample and Drive building);
- Roads; and
- Fences.

A comprehensive environmental site assessment would be conducted to determine if there are any sources or paths of contamination and to identify environmental receptors and develop remedial alternatives if applicable. Phase I of the site assessment consists of a records review, site visit, regulatory review, and hydrogeological review to determine if environmental contamination, which may result in future environmental liability is likely to be present at the property. Phase II of the site assessment consists of on-site sampling to determine if environmental issues exist. A sampling and

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[9] Decommissioning also is described as "retirement" in the NGS Operating Agreement.

analysis plan would be developed to identify sample locations, sampling methodologies, analytical parameters, and a quality assurance plan.

The equipment required and the general sequence for decommissioning includes:

- Following any asbestos abatement, equipment removal and demolition would be performed by heavy equipment including cranes, loaders, and excavators.
- Backfill, earthmoving, and compaction would be performed using scrapers, front-end loaders, trucks, dozers, and compaction equipment.
- Power, potable water, sanitary facilities, and communication services for dismantling.
- Survey equipment systems and ascertain that no fuels remain.
- Ensure coal has been removed from storage areas, conveyors, hoppers, and feed equipment.
- Ensure fuel oils have been drained and purged from tanks, piping, and pump equipment.
- Ensure sludges and residues have been removed and equipment has been cleaned.
- Recover glass, paper, cardboard, plastics, and metals for recycling.
- Demolish and remove:
  - Boiler room equipment and piping
  - Turbine room equipment and piping
  - Roofing and siding
  - Precipitator area
  - Flue gas desulphurization area
  - Chimneys
  - Boiler room structure (trusses, columns, beams, floors, grating, platform stairways)
  - Turbine room structure (trusses, columns, beams, floors, grating, platforms, stairways)
- Perform sequence similar to that described under demolition for other areas.
- Site closure includes:
  - Remediate any contaminated soils found during demolition
  - Plant native vegetation

Except for hazardous materials and parts and material salvaged, recycled, or sold for scrap, it is anticipated that demolished structural material would be placed within a landfill area on the NGS site, and covered with soil. In accordance with 1969 Lease and Lease Amendment No. 1 (or a leasing agreement with the Navajo Nation having similar terms as the 1969 Lease and Lease Amendment No. 1) the coal ash landfill would be left in place and capped with soil material, and revegetated. Hazardous materials would be transported and disposed in compliance with the Resource Conservation and Recovery Act and other applicable requirements. Decommissioning of the BM&LP Railroad would involve removal of overhead power lines, rails, and ties.

As required in the 1969 Lease and Lease Amendment No. 1 (or a leasing agreement with the Navajo Nation having similar terms as the 1969 Lease and Lease Amendment No. 1) the land would be restored as closely as possible to original condition where the surface of any leased land has been modified or improved. The areas that do not contain permanent facilities would have all nonindigenous material removed from the surface and the area would be filled and graded to provide proper drainage; however, in accordance with the lease, there would be no attempt to return the leased lands or the ROW to the preconstruction elevations. All restored land would be covered with topsoil indigenous to the area, and revegetated with native plants in order to meet the lease requirements (**Appendix 1B**).

2.3.1.2 Proposed Kayenta Mine Complex

Under the Proposed Action, the Kayenta Mine and former Black Mesa Mine areas would be combined into one permit area consisting of 62,930 acres; the proposed combined area would be called the KMC. The proposed KMC would have a LOM plan equivalent to the life of the NGS and would continue to supply coal to the NGS through the year 2044. OSMRE approvals to mine would continue to be subject to 5-year permit renewals. The volume of coal that would be mined in the 2020-2044 timeframe would depend on the decision to implement a NGS 3-Unit Operation or 2-Unit Operation (requiring delivery of approximately 8.1 million tons per year (tpy) of coal or 5.5 million tpy of coal, respectively). Pit locations proposed for mining would be the same for both coal production scenarios; however, under the 5.5 million tpy scenario, the rate of mining would proceed more slowly than the 8.1 million tpy scenario, and therefore no mining would occur in Mining Area N-10 (**Table 2-5**). As a consequence, the total amount of surface disturbance across all mining units would be less for the 5.5 million tpy scenario than the 8.1 million tpy scenario. The previously approved LOM plan (which could provide coal through at least 2026 without revisions) is designed for 8.1 million tpy production. The LOM plan may be modified periodically to make timing adjustments within each coal resource area. The baseline for evaluating surface disturbance estimates for the period from 2020 through 2044 is the planned disturbance as of December 23, 2019 (PWCC 2012 et seq.).

Table 2-5 Schedule for Coal Mining by Coal Resource Area

Coal Resource Area	NGS 3-Unit Operation (mined coal 8.1 million tpy)	NGS 2-Unit Operation (mined coal 5.5 million tpy)
J-19	2020-2027	2020-2033
N-9	2020-2028	2020-2025
J-21/J-21W	2020-2039	2020-2041
N-10	2029-2043	--
N-11E	2039-2044	2025-2044

No new mining would occur at the former Black Mesa Mine area. The support facilities located in the former Black Mesa Mine area that are being used through 2019 to support mining at the Kayenta Mine would continue to be used through 2044, and would be administered through the Permanent Program Permit AZ-0001E. Lands within the former Black Mesa Mine that remain undisturbed would continue to be administered under the Pre-Law or Initial Program requirements, based upon when they were most recently disturbed. Any new land disturbance proposed in the former Black Mesa Mine area would be subject to compliance with NEPA.

Under the Proposed Action, all mining through the LOM would occur within the existing Kayenta Mine area. Mining would continue in the three existing coal resource areas (N-9, J-19, and J-21) and would be initiated at two new coal resource areas for the 8.1 million tpy scenario (N-10 and N-11 Extension) and at one new coal resource area for the 5.5 million tpy scenario (N-11 Extension). Mining in the J-21 coal resource area would progress onto Hopi-owned surface after 2020; Hopi-owned surface is designated as coal resource area J-21W. **Figure 2-1** depicts the coal resource areas where mining operations would occur from 2020 to 2044. **Table 2-6** provides a schedule for mining from 2020 through 2044 at each of the individual coal resource areas. Mining at coal resource area N-9 would occur during the earlier years of this time period, and shift to coal resource area N-11E. For mining associated with both the 3-Unit Operation and 2-Unit NGS Operation, mining would occur in coal resource area J-21/J-21W for most of the period, until 2039 or 2041.

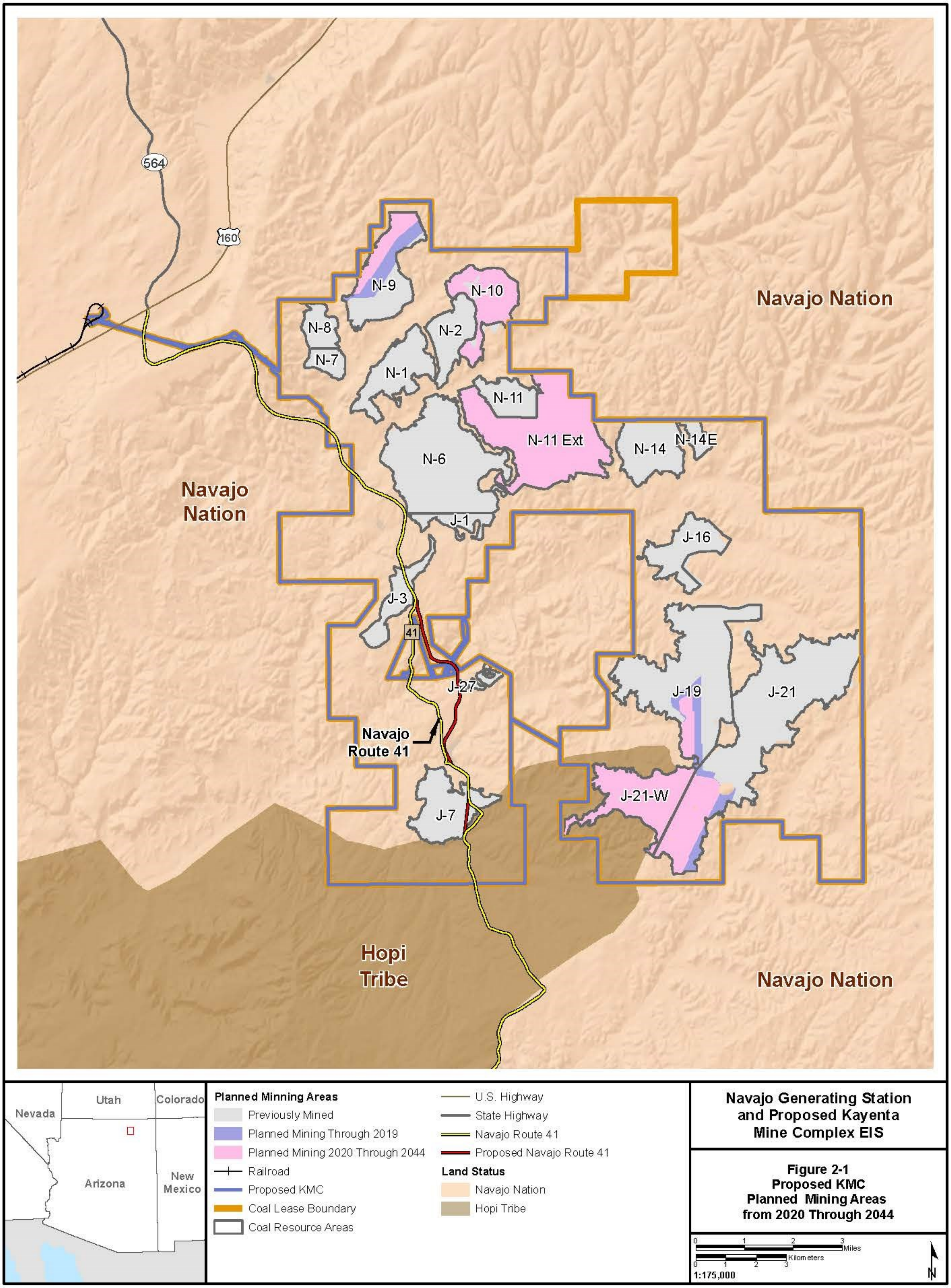

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Table 2-6 Proposed Production by Coal Resource Area 2020 through 2044 (based on 3-Unit Operation)

Coal Resource Area	Production 2020-2024 (tonsX1000)	Production Beyond 2024 (tonsX1000)
J-19	11,617.0	9,680.9
J-21	10,805.9	43,076.2
J-21 West	7,093.4	46,781.9
N-9	10,750.9	104.7
N-10	0	24,861.4
N-11E	0	68,532.0

Under the Proposed Action, vegetation clearing, topsoil removal and mining methods would continue. The existing coal preparation facilities at the coal resource area J-28, and mine areas N-11 and N-8 would be used; no new coal preparation facilities would be constructed. Coal removed from the northern coal resource areas (N-9, N-10, and N-11E) would be hauled by truck to the N-11 coal preparation area, where it would be crushed, screened, and transferred by conveyors to the N-8 coal preparation area. Coal removed from the southern coal resource areas (J-19 and J-21/J-21W) would be hauled by truck to the J-28 coal preparation area where it would be processed and conveyed to the N-8 coal preparation area. At the N-8 coal preparation area, the coal would be stockpiled, blended, or conveyed directly to the silo and rail load-out.

Table 2-7 provides a summary of proposed KMC activities that would occur from 2020 through 2044 under the Proposed Action. As indicated previously, the infrastructure components required to support the higher and lower coal production rates would be the same. The primary source of mine plan information for the proposed KMC is the LOM Plan Significant Revision that was submitted to OSMRE by PWCC in March 2015 (PWCC 2012 et seq.).

Table 2-7 Proposed KMC Activities – 2020-2044

	Proposed Action (5.5 and 8.1 Million tpy Coal Production)
Permit and Affected Areas	The Kayenta Mine and former Black Mesa Mine areas would be combined into the proposed KMC. Activities at both areas would be administered through the Permanent Program Permit AZ-0001E. Affected lands would fall into either Pre-Law, Initial Program or Permanent Program requirements based on when the lands were most recently affected.
Mining Requirements	8.1 million tpy: Continued mining in coal resource areas N-9, J-19, and J-21. Mining in new coal resource areas N-10, N-11 Extension, and J-21W. 5.5 million tpy: Same mining areas as the 8.1 million tpy scenario except no mining would occur in coal resource area N-10. LOM extended through 2044. No change to mining methods. Additional topsoil stockpiles would be created as topsoil salvage occurs in new mine areas.
Support Facilities	Use of the support facilities located on the former Black Mesa Mine would continue through the LOM.
Coal Handling and Storage	No changes proposed in coal preparation facilities. Coal mined at coal resource areas N-10 and N-11 Extension would be handled at the existing N-11 coal preparation area.

Table 2-7 Proposed KMC Activities – 2020-2044

	Proposed Action (5.5 and 8.1 Million tpy Coal Production)
Water Use and Management	New temporary sedimentation ponds would be constructed through the LOM. Predicted groundwater use (both mining scenarios): 2020-2044 1,200 acre-feet per year. 2045-2047 500 acre-feet per year (reclamation). 2048-2057 100 acre-feet per year (vegetation establishment and bond release).
Roads	No new primary or ancillary roads are proposed for mining in new coal resource areas. Primary and ancillary routes already have been established. Pit ramps would continue to change within existing and new mine areas as mining progresses.
Navajo Route 41	PWCC proposes to reconstruct Navajo Route 41 in its approximate original location and reclaim the reroute as approved.
Fuel storage, Vehicle Maintenance areas, and Explosives Storage	No changes proposed to existing fuel storage, vehicle maintenance areas, and explosives storage.
Solid and Hazardous Waste Disposal	No changes proposed to solid and hazardous waste disposal.
Airfield	No changes proposed to existing airfield facilities.
Air Quality Control and Monitoring	Continued operation of existing monitoring activities and locations.
Water Quality and Quantity Monitoring	Continued operation of existing monitoring activities and locations.
Jurisdictional Bonding Requirements	With combination of the Kayenta Mine and former Black Mesa Mine as the proposed KMC, the reclamation bond would be revised to include the former Black Mesa Mine facilities being used in support of operations at the Kayenta Mine. The bond would be periodically reviewed and adjusted as necessary. The initial and Pre-Law areas at the Kayenta Mine and the former Black Mesa Mine are bonded for reclamation through lease bonds.
Mine Reclamation Requirements	Disturbed areas would be reclaimed to approximate landforms that existed prior to mining and revegetated using vegetation similar to surrounding areas to support the post-mining land use of rangeland grazing, wildlife habitat, and cultural plantings.
Abandonment/ Decommissioning	Facilities would be abandoned and removed after 2044 unless approved by OSMRE and the Navajo Nation as a permanent facility.
Community	Community efforts through 2019 would continue through 2044, including the provision of potable water; emergency medical services; snow removal; water hauling for livestock; firewood from slash piles; coal (free or at a cost) to members of the community; managed grazing on reclaimed lands; and, the provision of certain compensation for residents within or near mining and related activities.

Additional topsoil stockpiles and additional drainage and sediment control structures would be added as mining progresses. No other new support facilities are anticipated for the LOM.

The mine's work force would remain at or near historical levels through the LOM under the NGS 3-Unit Operation, which is approximately 440 full-time employees. For the NGS 2-Unit Operation, employment is estimated at 299 full-time employees. Existing programs supporting community water supply initiatives and providing access to coal and timber would continue.

In the years 2040 through 2044, additional equipment would be added to account for the increase in the stripping ratio or amount of overburden required to be removed in relation to the amount of coal to be mined. This ratio would increase in 2040 from approximately 5:1 to 7:1. The resulting need for additional equipment would be handled through contractor equipment and associated operators.

Mine reclamation activities including grading, spoil sampling, subsoil and topsoil replacement and seeding would be conducted in the same manner as the historical operations. Reclamation plans would be updated periodically to adjust for changes in timing or unique land conditions and reviewed and approved by OSMRE for compliance with federal regulations. Proposed KMC reclaimed areas would be monitored for reclamation success with reseeding and repair of any erosional features which have formed on reclaimed areas, as needed. No support facility reclamation would be completed until the cessation of mining in 2044.

Ambient air quality and meteorological monitoring would continue at sites within the proposed KMC under the Proposed Action. Continued operation of hydrologic monitoring sites including wells, springs, and streams for sampling water quality and quantity at the Kayenta Mine and at the former Black Mesa Mine also would continue under the Proposed Action, and reporting requirements to OSMRE would remain the same as under historical operations.

2.3.1.2.1 Navajo Route 41 Realignment

As part of the Proposed Action, Navajo Route 41 would be realigned (see **Figure 2-1**). Navajo Route 41 is an open range, paved/graveled road which does not have a recorded ROW and receives limited maintenance. PWCC provides maintenance of Navajo Route 41 from its intersection with U.S. Highway 160 to the southern permit boundary of the mine site to ensure safe employee access to the mine site; however, no agreement for maintenance exists. Other portions of the route are not routinely maintained.

Two portions of Navajo Route 41 are proposed for realignment by PWCC that were initially rerouted after consultation with OSMRE, the Navajo Transportation Department, and Bureau of Indian Affairs. The first portion to be realigned is located from south of the former Black Mesa Mine Reclamation Complex to south of the former Black Mesa Mine facilities area. The original Navajo Route 41 alignment was within PWCC's mine area and was used by PWCC as a primary mine road for mine traffic; public traffic also was allowed. OSMRE requested that PWCC separate the public traffic from the mine traffic and PWCC created the existing alignment for Navajo Route 41. As part of the LOM plans, PWCC proposes to realign Navajo Route 41, placing the route back in its approximate original configuration along PWCC's now-abandoned primary mine road. The realignment would straighten the road and make the route a more consistent elevation, eliminating a steep drop and curve (PWCC 2012 et seq.).

A second portion of Navajo Route 41 was temporarily rerouted to allow maximum coal recovery in the J-7 mine area of the former Black Mesa Mine as shown on **Figure 2-1**. Mining in the J-7 mine area was completed in 2005 and reclamation of the mine area was completed in 2010. PWCC plans to realign Route 41 in approximately the same location as the original alignment using the J-7 Ramp #1 and haul road system. A portion of the realignment also crosses Hopi tribal land.

Realignment of both sections is expected to be completed no later than 2025. PWCC would submit a new permit revision for appropriate regulatory approval with the proposed alignment and a request to permit these roads as permanent roads. The proposed construction of these realignment portions is included in the Proposed Action.

2.3.1.2.2 Decommissioning and Abandonment, Disposition of Mine Facilities and Final Reclamation

Facility removal, backfilling, grading, topsoil replacement and revegetation is expected to take 2 to 3 years after cessation of mining at the end of 2044. Final reclamation release, lease relinquishment and termination of jurisdiction is expected to take approximately 10 to 15 years after mining ends to allow for the revegetation to become established and ensure long-term stability of reclaimed areas (a minimum of 10 years after reclamation pursuant to Surface Mining Control and Reclamation Act). A reclamation bond would be maintained for the lands affected under the Permanent Program until final reclamation release. Water would continue to be pumped from groundwater wells for dust control and to assist with reclamation activities at the rate of approximately 500 acre-feet per year from 2045 through 2047; groundwater withdrawals would continue at the rate of approximately 100 acre-feet per year from 2048 through 2057. Mine closure and reclamation activities, which are detailed in the permit application package, would include the following:

- Completion of approved mine plan through 2044 and cessation of mining after 2044.
- Decommissioning and removal of surface structures, facilities, and mining equipment after 2044.
- Completion of the approved reclamation process for mine areas, facilities areas, and any other disturbance not approved as permanent facilities.
- Monitoring of reclaimed areas until the final bond release.
- Release of reclamation bond.

Mine facilities with economic value would be decommissioned and the materials removed for salvage. Non-salvageable facilities would be buried. Concrete foundations and sub-bases would be removed or buried in place if approved by OSMRE. If the foundations are buried in place, the cover over these structures would be a minimum of four feet. Grading, topsoil replacement and seeding would occur for the facilities areas as described in the approved permit application package.

2.3.1.3 Transmission Systems and Communication Sites

Under the Proposed Action, no construction, major replacement, or other activities beyond continued operation and as-needed maintenance are anticipated for the transmission line systems, substations, and communications sites. Ongoing maintenance, repair, replacement, and improvement of the transmission lines would continue. These activities include aerial and ground inspection, repair and replacement of transmission system components, and ROW vegetation treatment to reduce safety hazards. The majority of all inspection and maintenance activities would occur along the existing ROW, serviced by existing roads leading to the regional highway system. In the event that new roadways are required to access the transmission line ROW, the transmission line operators would apply for and obtain temporary access permits to conduct repair and maintenance activities from the applicable land management agency. Operation and maintenance activities are further described in **Appendix 1B**.

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

2.3.1.4 Community Assistance and Environmental Measures

Based on the results of public scoping, and the issues and concerns described in this EIS, Reclamation and the project proponents (SRP and PWCC) have developed measures and associated commitments to provide assistance to the communities directly affected by the Proposed Action and alternatives, and to provide environmental monitoring and other protection measures in response to identified environmental impacts. All the project components are currently operating, and are subject to existing federal regulation, and future authorizing actions (**Table 1-1**). A discussion of best management practices (BMPs) mitigation and voluntary commitments that are currently in place are discussed in Chapter 4.0, Mitigation and Voluntary Commitments. Best management practices for NGS and the proposed KMC also are included in **Appendix 1B** and **1D**, respectively.

2.3.1.4.1 Community Assistance

In response to concerns received during scoping, and interviews during the course of preparing this EIS, quality of life concerns were raised by community members living within and adjacent to the proposed KMC. The following measures were developed by the project proponents (i.e., NGS Participants and PWCC) to address these concerns.

Proponent-sponsored Stove Replacement Program

Need for the measure:

- Many Navajo community members burn both wood and coal for heating and cooking in the area surrounding the proposed KMC. PWCC provides community residents with coal for winter heating. Stoves used for these purposes are of varying quality and efficiency, and in some cases, stoves are improvised from available materials. This measure would addresses a primary quality of life concern that the use of poor quality or improperly ventilated stoves by Navajo residents for indoor heating and cooking can lead to poor indoor air quality and potential health impacts.

Measure description:

- If USEPA certified coal stoves are available, SRP (on behalf of the NGS Participants), and in coordination with PWCC and Navajo Nation Environmental Protection Agency(NNEPA), would establish a stove replacement and installation program to benefit the residents within and surrounding the mine permit area. SRP would coordinate with NNEPA to provide input to the program.
- The program would be established between 2020 and 2025; up to $1M will be made available by SRP for the exchange program (it is estimated that an EPA certified coal/wood stove would cost approximately $5000 installed). Thus, the $1M in funding would provide for approximately 200 stoves.
- If funds remain at the end of 2025, the funds would be deposited in the NGS Community Fund that was established when Lease Amendment No. 1 is signed by the non-federal NGS Participants; NGS would coordinate with NNEPA to provide funding for key Navajo program(s) that address air quality concerns near the mine lease area.

Proponent-sponsored KMC Community Liaison

Need for the measure:

- During meetings with residents living within the proposed KMC during the preparation of this EIS, concerns were expressed about the frequency and detail of communications on mine activities that affect the daily lives of residents. These concerns focused on periodic changes in mining location and residential relocations, access to grazing areas and surface water, and exposure to mining-generated dust and noise (see Sections 3.16, Public Health, and Section 3.18, Socioeconomics).

Measure description:

- PWCC would continue to provide one full time equivalent employee for a tribal Community Liaison position for the proposed KMC area and the Black Mesa Community. PWCC would direct and oversee, and Reclamation and OSMRE would coordinate with and provide input to PWCC regarding this position. The Community Liaison would interface with residents, tribal departments (Navajo Nation and Hopi Tribe), project proponents, and affected federal agencies on a regular basis, providing a mechanism to more pro-actively address resident concerns during mining, and plan for the transition to post-mining use of the area. A communications framework for regularly scheduled reporting on issues and progress would be developed and carried out by this position.

- The effectiveness of the position would be subject to periodic reviews planned and organized by PWCC no less than once every 5 years. This review would be led by Reclamation and include PWCC, OSMRE, residents, tribal departments (Navajo Nation and Hopi Tribe), Project Proponents, and affected federal agencies. This review would recommend changes to the way in which PWCC addresses resident concerns during mining, effectiveness of communications, the transition to post-mining use of the area, and a determination if the Liaison role should be continued until the next 5-year review.

Reclamation-sponsored Technical Support

Need for the measure:

- During meetings with residents living within the proposed KMC during the preparation of this EIS, concerns were expressed about the lack of potable water service to homes near the mine. The lack of potable water service across the Navajo Nation is well documented. As mentioned in Section 3.18.3.1, the Navajo Tribal Utility Authority estimates that 15,000 families are without access to electricity and many more are without access to running water. There are a number of municipal water projects on the Navajo Nation in various stages of planning to address this issue (e.g., the Many Mules Water Project described in Section 3.18.3.1).

Measure description:

- Through its existing Memorandum of Understanding with the Navajo Nation, first established in 2001 and reaffirmed by the Commissioner of Reclamation and Navajo Nation President in 2016, Reclamation would provide technical assistance to promote water development projects across the Navajo Nation. Technical assistance would be provided in coordination and cooperation with the Navajo Nation government, and is subject to appropriations, authority and program criteria.

2.3.1.4.2 Proponent Committed Environmental Measures

This section provides a summary of measures that were developed in response to identified environmental impacts, or need for environmental monitoring.

2.3.1.4.2.1 Water Resources

WR-1 Black Mesa USGS Water Resources Monitoring

Need for the measure:

The USGS water resources monitoring program that was initiated in the 1970's has provided essential information used to describe environmental impacts in this EIS, and input to groundwater modeling. The data resulting from a continuation of existing monitoring at selected locations would assist in confirming impacts predicted in this EIS, and would provide inputs to the Kayenta Mine regional groundwater model.

Measure description:

PWCC would continue to financially support the existing U.S. Geological Survey (USGS) Black Mesa water resources monitoring program on a proportional share basis along with the other participants in the program. PWCC would continue to interact with the USGS, Navajo Nation, Hopi Tribe, OSMRE, and other participating agencies to determine ongoing water resources monitoring needs sufficient to maintain the program as needed.

WR-2 Update of the D-Aquifer and N-Aquifer Groundwater Flow Model

Need for the measure:

Management of groundwater and surface water resources on Black Mesa will require comparisons of measured and modeled water levels over the next 20 years to make decisions. Updating and modifying the model to better characterize the groundwater system and the effects of pumping would assure that decisions are based on the best available information.

Measure description:

In or about the year 2036, PWCC and a groundwater modeling team would update and perform re-calibration of the existing multi-layer D- and N-Aquifer groundwater flow model. This work would incorporate new, updated inputs for: observed water levels in wells; stream baseflow; conditions at springs and other pertinent discharge locations; and mine-related, community, and other pumping withdrawals. Data and information gained from the regional cooperative monitoring program (see WR Monitoring Measure 1, above) would be used as inputs and for calibration. Techniques and routines for modeling and calibration also would be reviewed and updated as necessary, to ensure that improvements in groundwater modeling technology are appropriately applied. Through coordination with appropriate agencies, groundwater modeling outputs would be tailored to the needs of applicable environmental regulatory requirements at the time.

WR-3 Water Quality Sample Analysis and Reporting Limits

Need for the measure:

Since water quality standards and approved laboratory analytical methods change over time, the mine-related water quality monitoring program will need to maintain coordination with appropriate regulatory agencies to collect applicable data.

Measure Description:

All surface water and groundwater quality analyses at the KMC would continue to be conducted and reported according to approved laboratory analytical methods and reporting limits determined and approved through coordination with OSMRE, the NNEPA, and the Hopi Tribe Water Resources Program.

2.3.1.4.2.2 Biological Resources

During formal consultation under Section 7 of the Endangered Species Act of 1973, Reclamation, the U.S. Fish and Wildlife Service, the key cooperating agencies, and SRP (on behalf of the NGS Participants) initiated development of Conservation Measures that would offset impacts to listed and candidate species. These Conservation Measures are presented in the biological resource sections in this EIS for individual species, as well as in the Biological Assessment, Chapter 3.0 Conservation Measures. These Conservation Measures include new measures designed to protect fish and wildlife species and their designated habitats, as well as BMPs that have been included in prior transmission line consultations conducted for the STS and WTS, or similar transmission lines, or are included in the Navajo Project Operation and Maintenance Plan (**Appendix 1B**). All biological Conservation Measures used in this EIS are presented in the Biological Assessment released concurrently with this Draft EIS.

2.3.2 Partial Federal Replacement Alternatives

As described previously in Section 2.2.3.2, technical and economic analyses indicated the concept of PFR would meet the purpose and need of the Proposed Action. Through the public scoping process, three central themes with respect to alternatives development became evident: 1) seek to minimize energy costs to the CAP; 2) explore renewable energy technology as an economically viable option; and 3) consider tribal socioeconomic impacts.

The concept of partial replacement is analyzed in this EIS through three PFR alternatives consisting of the use of a power purchase agreement to acquire energy from a non-coal source under a specified schedule, displacing an equivalent amount of power from the federal share of NGS generation. To facilitate the comparison of the PFR alternatives impacts to those of the Proposed Action, the PFR alternatives are defined conceptually as obtaining 100 MW up to 250 MW from one of three sources: the lowest cost lower emitting energy source (i.e., natural gas); a renewable energy source; and a source of renewable energy located on tribal land. Using a consistent generating capacity range allows the comparison of differences to be focused on the environmental and socioeconomic impacts from the sources of replacement power, including the particular constraints and flexibilities that each possesses.

Although the three PFR alternatives are consistent in the specification of 100 MW to 250 MW of peak energy to be obtained from a lower-emitting source, they differ in the source of the replacement power and energy, the total amount of energy provided over time, and commensurately, the amount of energy by which NGS would be curtailed. Regardless of the mix of power generation options that could result from implementation of a partial federal share replacement, the quantity of power delivered to the CAP system would remain the same.

The following PFR alternatives considered in the EIS address one of the three central themes identified during public scoping with respect to alternatives development; additional summary level detail on each alternative can be found in subsequent sections, and **Appendix 2A** provides a detailed description of each PFR alternative and the anticipated changes to NGS and associated facilities and the proposed KMC.

For all PFR alternatives, the use, operation, maintenance and repair/replacement of the transmission systems and communication sites would be the same as described for the Proposed Action.

2.3.2.1 Natural Gas PFR Alternative

The selected quantity of firm power between 100 MW and 250 MW would be contracted for under a long-term power purchase agreement from existing natural gas generation sources, with energy supplied to the CAP on a 24-hour per day, 7-day per week basis. NGS would curtail its output by the corresponding amount, continuing operations to meet the remaining federal share and market surplus. This alternative utilizes existing natural gas resources to reduce net emissions and minimize resulting cost increases,[10] while maintaining the availability and value of surplus energy from NGS at about the same quantities as under the Proposed Action. The following sections describe how the project component operations and employment (NGS, proposed KMC, and the transmission system) would be modified by the reductions in NGS energy output. See **Appendix 2A** for detailed description of the Natural Gas PFR Alternative and the anticipated changes to NGS and associated facilities, the proposed KMC, and transmission systems.

[10] All PFR alternatives would have an incremental cost increase versus power for CAP from NGS alone (National Renewable Energy Laboratory 2015a); natural gas was the least-cost technology.

2.3.2.1.1 Navajo Generating Station

Table 2-8 provides estimates of NGS and the Natural Gas PFR Alternative annual energy output, as well as the changes in energy deliveries to CAP from NGS. Reductions in deliveries to CAP from NGS under this PFR alternative would be offset by energy purchases from a natural gas source, such that the sum of the federal energy from NGS supplied to CAP and the PFR alternative energy supplied to CAP would equal the 2.7 terrawatt-hours per year of energy delivered to CAP by the Proposed Action (either 3-Unit Operation or 2-Unit Operation). The opportunity for sales of surplus energy would remain the same for both the Proposed Action and the Natural Gas PFR Alternative, but the amount of potential NGS surplus energy would be slightly less under the 2-Unit Operation due to the reduction in the federal share of energy for a 2-Unit Operation.

Table 2-8 Annual NGS Proposed Action and Natural Gas PFR Energy Output

Configuration	Proposed Action	Natural Gas PFR 100-MW Reduction	Natural Gas PFR 250-MW Reduction
NGS - 3-Unit Operation, 547-MW Federal Share			
Federal Energy from NGS (TWh/yr) [1]	4.17	3.29	1.98
Federal Energy from NGS Supplied to CAP (TWh/yr)	2.70	1.82	0.51
Energy from PFR source delivered to CAP (TWh/yr)	--	0.88	2.19
NGS Energy Available as Surplus (TWh/yr)	1.47	1.47	1.47
NGS – 2-Unit Operation, 540-MW Federal Share			
Federal Energy From NGS (TWh/yr)	4.12	3.24	1.93
Federal Energy Supplied to CAP from NGS (TWh/yr)	2.70	1.82	0.51
Energy from PFR source delivered to CAP (TWh/yr)	--	0.88	2.19
NGS Energy Available as Surplus (TWh/yr)	1.42	1.42	1.42

[1] TWh/yr = terawatt-hours per year. 1 terawatt equals 1 trillion (1,000,000,000,000) watts.

No modifications to NGS coal handling equipment, generation equipment, water delivery, and waste disposal procedures would be required to implement the Natural Gas PFR Alternative. There would be a reduction in BM&LP Railroad trips, as well as water and chemical use proportional to the reduced quantity of coal burned for energy generation. These reductions would range from 5 to 19 percent less than under the Proposed Action.

It is anticipated that fewer direct, indirect and induced employment would occur in response to lower energy output. **Table 2-9** provides a general estimate of regional employment changes under the Natural Gas PFR Alternative relative to the Proposed Action.

Table 2-9 Regional Employment Associated with NGS under the Natural Gas PFR Alternative

Regional Employment	Regional Employment Numbers			
	3-Unit Operation NGS		2-Unit Operation NGS	
	Natural Gas 100-MW Reduction	Natural Gas 250-MW Reduction	Natural Gas 100-MW Reduction	Natural Gas 250-MW Reduction
New Regional Jobs Tied to Alternative Power	0	0	0	0
Total Regional Jobs (direct, indirect & induced): Typical Year	2,077 87 fewer than Proposed Action	1,999 165 fewer than Proposed Action	1,535 81 fewer than Proposed Action	1,453 163 fewer than Proposed Action

Under the Natural Gas PFR Alternative, decommissioning and final reclamation of the NGS and associated facilities and BM&LP Railroad would be the same as described for the Proposed Action.

2.3.2.1.2 Proposed Kayenta Mine Complex

Table 2-10 provides estimates of reductions in coal mined at the Kayenta Mine under the Natural Gas PFR Alternative in relation to the Proposed Action. No modifications to proposed KMC coal mining and handling equipment, mining procedures and reclamation, groundwater use, and waste disposal procedures would be required to implement the Natural Gas PFR Alternative. There would be a reduction in energy required to mine coal, and less surface disturbance from mining. On a proportional basis, these reductions would range from 5 to 18 percent less than under the Proposed Action.

Table 2-10 Annual Coal Mined for NGS Under the Natural Gas PFR Alternative

Configuration	Proposed Action	Natural Gas PFR 100-MW Reduction	Natural Gas PFR 250-MW Reduction
NGS – 3-Unit Operation			
Annual Coal Mined (in million tons) Percentage Difference from Proposed Action [1]	8.1 NA	7.7 -5%	7.1 -12%
NGS – 2-Unit Operation			
Annual Coal Mined (in million tons) Percentage Difference from Proposed Action[1]	5.5 NA	5.1 -7%	4.5 -18%

[1] Differences in tons of coal are relative to the base tonnages for the corresponding 3-Unit Operation or 2-Unit Operation under the Proposed Action.

Table 2-11 provides estimates of regional employment changes as the result of less coal mined under the Natural Gas PFR Alternative. As indicated in the table, the greatest employment reductions would be associated with the 250-MW NGS energy replacement operation.

Table 2-11 Regional Employment Associated with the Proposed Kayenta Mine Complex Under the Natural Gas PFR Alternative

Regional Employment	Regional Employment Numbers			
	3-Unit Operation NGS		2-Unit Operation NGS	
	Natural Gas 100-MW Reduction	Natural Gas 250-MW Reduction	Natural Gas 100-MW Reduction	Natural Gas 250-MW Reduction
Employment (direct, indirect and induced) – Typical Year	1,573 75 fewer than Proposed Action	1,453 195 fewer than Proposed Action	1,052 77 fewer than Proposed Action	939 190 fewer than Proposed Action

Decommissioning and final reclamation of the proposed KMC would occur as described under the Proposed Action.

For all PFR alternatives, the use, operation, maintenance and repair/replacement of the transmission systems and communication sites would be the same as described for the Proposed Action.

2.3.2.2 Renewable PFR Alternative

Under the Renewable PFR Alternative the selected quantity of firm power between 100 MW and 250 MW would be contracted for under a long-term power purchase agreement from existing renewable generation sources, with energy supplied to the CAP during a defined time period of 14 hours per day, 7 days a week, a duration which generally corresponds to the period of high commercial and residential demand and the availability of renewable generation in the southwest. Generation from two or more sources would be required to supply the necessary level of power for the defined duration. The power purchase agreement for this alternative would require that “firming” be included for the defined period of delivery to maintain reliability during short-term fluctuations in output (e.g., cloud cover); however, “firming” is not intended to augment output from the renewable source to achieve a steady 100 MW to 250 MW over the entire period. [11] The net result would be replacement power providing an average of between 58.3 MWh and 145.8 MWh per hour over the course of a 24-hour period.

Energy deliveries from the renewable sources would be monitored over time and curtailment at NGS scheduled to achieve the necessary reduction in NGS production and associated reductions in coal combustion. The curtailment would not necessarily be concurrent with the scheduled delivery of energy from the renewable sources to the CAP, however reductions in the amount of power produced at NGS would occur over a yet-to-be determined period of time, i.e., monthly, quarterly or yearly, to total that supplied by renewable sources. Non-concurrent curtailment provides flexibility to optimize operations of NGS, while still assuring achievement of the established levels of emission reductions, and maintains the availability and value of surplus energy from NGS at about the same quantities as under the Proposed Action.

The following sections describe how the project component operations and employment (NGS, proposed KMC, and the transmission system) would be modified by the reductions in NGS energy output compared to the Proposed Action. See **Appendix 2A** for detailed description of the Renewable PFR alternative and the anticipated changes to NGS and associated facilities, the proposed KMC, and transmission system.

[11] “firming” refers to a secondary source of power to compensate for the normal variability and irregularity of energy generation from a solar facility, i.e., if part of the array is shaded. Renewable sources cannot serve as a “firming” source because they do not offer the necessary reliability and responsiveness.

2.3.2.2.1 Navajo Generating Station

Table 2-12 provides estimates of the Proposed Action and the Renewable PFR Alternative annual energy output, as well as the relative reduction in energy deliveries from NGS to CAP, which would be offset by energy purchases from a renewable energy source. See the Natural Gas PFR Alternative for how the alternative energy supplied to CAP relates to NGS energy delivery to CAP, and the quantity of NGS energy available for surplus.

Table 2-12 Annual Energy Output for the Proposed Action and Renewable PFR Alternative

Configuration	Proposed Action	Renewable PFR 100-MW Reduction	Renewable PFR 250-MW Reduction
NGS – 3-Unit Operation, 547-MW Federal Share			
Federal Energy From NGS (TWh/yr) [1]	4.17	3.66	2.89
Federal Energy Supplied to CAP (TWh/yr)	2.70	2.19	1.42
Energy from PFR source delivered to CAP (TWh/YR)	--	0.51	1.28
NGS Energy Available as Surplus (TWh/yr)	1.47	1.47	1.47
NGS – 2-Unit Operation, 540-MW Federal Share			
Federal Energy From NGS (TWh/yr)	4.12	3.61	2.84
Federal Energy Supplied to CAP From NGS (TWh/yr)	2.70	2.19	1.42
Energy from PFR source delivered to CAP (TWh/YR)	--	0.51	1.28
NGS Energy Available as Surplus (TWh/yr)	1.42	1.42	1.42

[1] TWh/yr = terawatt-hours per year. 1 terawatt equals 1 trillion (1,000,000,000,000) watts.

No modifications to NGS coal handling equipment, generation equipment, water delivery, and waste disposal procedures would be required to implement the Renewable PFR Alternative. There would be a reduction in BM&LP Railroad trips, and water and chemical use proportional to the reduced quantity of coal burned for energy generation. These reductions would range from 3 to 11 percent less than under the Proposed Action.

It is anticipated that fewer employees would be required at NGS in response to lower energy output. **Table 2-13** provides a general estimate of regional employment changes under the Renewable PFR Alternative relative to the Proposed Action.

Table 2-13 Regional Employment Associated with NGS Under the Renewable PFR Alternative

Regional Employment	Regional Employment Numbers			
	3-Unit Operation NGS		2-Unit Operation NGS	
	Renewable 100-MW Reduction	Renewable 250-MW Reduction	Renewable 100-MW Reduction	Renewable 250-MW Reduction
New Regional Jobs Tied to Alternative Power	0	0	0	0
Total Regional Jobs (direct, indirect & induced): Typical Year	2,096 68 fewer than Proposed Action	2,054 110 fewer than Proposed Action	1,559 57 fewer than Proposed Action	1,509 107 fewer than Proposed Action

Under the Renewable PFR Alternative, decommissioning and final reclamation of the NGS and BM&LP Railroad would be the same as described for the Proposed Action.

2.3.2.2.2 Proposed Kayenta Mine Complex

Table 2-14 provides estimates of reductions in coal mined at the Kayenta Mine under the Renewable PFR Alternative in relation to the Proposed Action. Less reduction in coal mining would occur than the Natural Gas PFR Alternative because the renewable alternative energy source would not deliver as much energy to CAP, requiring more energy to be delivered from NGS. No modifications to the proposed KMC coal mining and handling equipment, mining procedures and reclamation, groundwater use, and waste disposal procedures would be required to implement the PFR alternative. There would be a reduction in energy required to mine coal, and less surface disturbance from mining. On a proportional basis, these reductions would range from 2 to 11 percent less than under the Proposed Action.

Table 2-14 Annual Coal Mined for NGS Under the Renewable PFR Alternative

Configuration	Proposed Action	Renewable PFR 100-MW Reduction	Renewable PFR 250-MW Reduction
NGS – 3-Unit Operation			
Annual Coal Mined (in million tons) Percentage Difference from Proposed Action[1]	8.1 NA	7.9 - 2%	7.5 - 7%
NGS – 2-Unit Operation			
Annual Coal Mined (in million tons) Percentage Difference from Proposed Action[1]	5.5 NA	5.3 - 4%	4.9 - 11%

[1] Differences in tons of coal are relative to the base tonnages for the corresponding 3-Unit Operation or 2-Unit Operation under the Proposed Action.

Table 2-15 provides estimates of regional employment changes as the result of less coal mined under this PFR alternative. As indicated in the table, the greatest employment reductions would be associated with the 250-MW energy replacement operation.

Decommissioning and final reclamation for the proposed KMC would occur as described under the Proposed Action.

Table 2-15 Regional Employment Associated with the Proposed KMC Under the Renewable PFR Alternative

Regional Employment	Regional Employment Numbers			
	3-Unit Operation NGS		2-Unit Operation NGS	
	Renewable 100-MW Reduction	Renewable 250-MW Reduction	Renewable 100-MW Reduction	Renewable 250-MW Reduction
New Regional Jobs Tied to Alternative Power	0	0	0	0
Total Regional Jobs (direct, indirect & induced): Typical Year	1,603 45 fewer than Proposed Action	1,534 114 fewer than Proposed Action	1,084 45 fewer than Proposed Action	1,017 112 fewer than Proposed Action

For all PFR alternatives, the use, operation, maintenance and repair/replacement of the transmission systems and communication sites would be the same as described for the Proposed Action.

2.3.2.3 Tribal PFR Alternative

The selected quantity of power would be contracted for under long-term power purchase agreement(s) from a new renewable energy facility constructed on lands of a tribe affected by actions under this EIS. Photovoltaic solar was selected over other renewable technologies for evaluation in the EIS because of its relatively low cost, reliability and schedule dependability, wide range of potential siting locations, and demonstrated utility scale capabilities in the region. Energy from photovoltaic solar would be dedicated to meet a portion of CAP demands during daylight hours of 12 hours a day, 7 days a week, a duration which generally corresponds to the period of time that an appropriately size photovoltaic solar facility would be able to reliably meet the 25-MW minimum curtail requirement for NGS and also deliver 100 MW to 250 MW to the CAP during the midday. [12] Energy production from the solar array would ramp up during the morning hours, level out during the middle of the day, and then ramp down during the evening. Similar to the Renewable PFR Alternative, the power purchase agreement for the Tribal PFR Alternative would require firming be included for the defined period of delivery to maintain reliability during short-term fluctuations in output (e.g., cloud cover); however, firming is not intended to augment output from the solar array to achieve a steady 100 MW to 250 MW over the entire period. The net result would be replacement solar power providing an average of between 38 MWH and 94.9 MWH per hour over the course of a 24-hour period.

Energy deliveries from the photovoltaic sources would be monitored over time and curtailment at NGS scheduled to achieve the necessary reduction in NGS production and associated reductions in coal combustion. NGS curtailment would not necessarily be concurrent with the scheduled delivery of energy from the photovoltaic sources to the CAP, however reductions in the amount of power produced at NGS would occur over a yet-to-be determined period of time, i.e., monthly, quarterly or yearly, to total that supplied by renewable sources. Non-concurrent curtailment provides flexibility to optimize operations of NGS, while still assuring achievement of the established levels of emission reductions, and maintains the availability and value of surplus energy from NGS at about the same quantities as under the Proposed Action.

[12] Based on typical photovoltaic solar productivity in northeastern Arizona over the course of a year, a system with a nominal capacity of 135 MW to 350 MW would be required to deliver 100 MW to 250 MW for several hours during the midday for transmission to the CAP. The differences between the 100 MW to 250 MW and the 135 MW to 350 MW specifications account for the effects of seasonal variation, inverter efficiency when converting power produced by the solar array to the form required for the grid, and meeting NGS operational requirements for curtailment (see **Appendix 2A**).

The Tribal PFR Alternative would reduce net emissions using renewable technology and provide an opportunity for NGS-affected tribes to develop photovoltaic solar capacity, while maintaining the availability and value of surplus energy from NGS at about the same quantities as under the Proposed Action. Based on industry experience, it is reasonable to assume that locating, designing, obtaining all necessary permits and approvals, and constructing a photovoltaic solar facility on tribal land could be accomplished to meet an in-service date of January 2025. For reclaimed lands at the proposed KMC to support a renewable energy facility, a change in the approved post-mining land use from livestock grazing and wildlife habitat to heavy or light industrial uses (solar or wind power facilities) would be necessary. Alternative post mining land uses, including uses for heavy or light industry, for the areas disturbed by mining at the proposed KMC are at the discretion of the Navajo and Hopi Tribes for their respective lands. Alternate uses can be authorized under an active Permit Application Package at the Tribes' request and OSMRE's approval per 30 CFR 816.33. As described in **Table 2A-7** the proposed KMC is not considered a suitable location to supply wind and solar energy to NGS. Federal action(s) associated with development of a photovoltaic solar facility on tribal land would necessitate compliance with the NEPA, Endangered Species Act, and National Historic Preservation Act, as appropriate, before a power purchase agreement would be authorized.

It is assumed that the Tribal PFR Alternative would require new facility construction on one or more sites. Regardless of the facility location(s) ultimately chosen, for purposes of the EIS, the following construction activity and consideration assumptions would apply:

- Land area required, including intertie ROW (5 miles at 100 feet in width): approximately 1,200 (100-MW facility) to 3,000 acres (250-MW facility) acres
- Duration of construction: 18 to 36 months
- Types of construction activities associated with construction of facility:
  - Survey, clear, grub and strip topsoil
  - Site grading and fencing
  - Construct roads and storm water detention
  - Construction foundations and install PV trackers and panels
  - Construct gen-tie line
  - Construct operations and maintenance buildings and substation
  - Construct parking areas and permanent roadways
  - Commission and test
- Project-related traffic:
  - Construction: light duty vehicles (cars and pickups), medium duty truck, semi-tractors and trailers, graders, backhoes, scrapers, compacters, welding rigs, cement delivery trucks, etc.
  - Operation: primarily light and medium duty trucks.
- Project workforce:
  - Construction: 335 to 400 average, higher temporary peaks
  - Operation: 9 – 13
- Water:
  - Construction: approximately 75 to 150 acre-feet during construction (100 MW) and 180 to 375 acre-feet (250 MW), primarily for use in making concrete, for dust suppression, potable use, and other miscellaneous uses.

- Operation: up to 10 acre-feet per year (100 MW) and up to 25 acre-feet per year (250 MW) to clean the PV arrays (to maintain conversion efficiency) and potable use.

The following sections describe how the project component operations and employment (NGS, proposed KMC, and the transmission system) would be modified by the reductions in NGS energy output compared to the Proposed Action. See **Appendix 2A** for detailed description of the Tribal PFR Alternative and the anticipated changes to NGS and associated facilities, the proposed KMC, and transmission system.

2.3.2.3.1 Navajo Generating Station

Table 2-16 provides estimates of NGS and the Tribal PFR Alternative annual energy output, as well as the relative reduction in energy deliveries to CAP (which is offset by energy purchases from a renewable energy source). See the Natural Gas PFR Alternative for how the alternative energy supplied to CAP relates to NGS energy delivery to CAP, and the quantity of NGS energy available for surplus.

Table 2-16 Annual Energy Output for the Tribal PFR Alternative

NGS Configuration	Proposed Action	Tribal PFR 100-MW Reduction	Tribal PFR 250-MW Reduction
NGS – 3-Unit Operation, 547-MW Federal Share			
Federal Energy From NGS (TWh/yr)[1]	4.17	3.83	3.33
Federal Energy Supplied to CAP (TWh/yr)	2.70	2.36	1.86
Energy from PFR source delivered to CAP (TWh/YR)	--	0.33	0.83
NGS Energy Available as Surplus (TWh/yr)	1.47	1.47	1.47
NGS – 2-Unit Operation, 540-MW Federal Share			
Federal Energy From NGS (TWh/yr)	4.12	3.78	3.28
Federal Energy Supplied to CAP from NGS (TWh/yr)	2.70	2.36	1.86
Energy from PFR source delivered to CAP (TWh/YR)	--	0.33	0.83
NGS Energy Available as Surplus (TWh/yr)	1.42	1.42	1.42

[1] TWh/yr = terawatt-hours per year. 1 terawatt equals 1 trillon (1,000,000,000,000) watts.

In **Table 2-17,** an estimate is provided for the number of construction and operations employees that would be required for a new photovoltaic facility constructed on tribal lands. Because a substantially larger number of solar panels and other infrastructure would be required for a 250-MW installation, a larger workforce would be required. **Table 2-17** also provides a general estimate of NGS employment changes under the PFR alternatives relative to the Proposed Action. It is anticipated that slightly fewer employees would be required at NGS in response to lower energy output.

No modifications to NGS coal handling equipment, generation equipment, water delivery, and waste disposal procedures would be required to implement the Tribal PFR Alternative. There would be a reduction in BM&LP Railroad trips, and water and chemical use proportional to the reduced quantity of coal burned for energy generation. These reductions would range from 2 to 8 percent less than under the Proposed Action.

Under the Tribal PFR Alternative, decommissioning and final reclamation of the NGS and BM&LP Railroad would be the same as described for the Proposed Action.

Table 2-17 Regional Employment Associated with NGS Under the Tribal PFR Alternative

	Regional Employment Numbers			
	3-Unit Operation NGS		2-Unit Operation NGS	
Regional Employment	**Tribal 100-MW Reduction**	**Tribal 250-MW Reduction**	**Tribal 100-MW Reduction**	**Tribal 250-MW Reduction**
New Regional Jobs Related to Alt. Power				
Construction	533 for 1.5 years	636 for 2.5 to 3 years	533 for 1.5 years	636 for 2.5 to 3 years
Operation	9	13	9	13
Total Regional Jobs (direct indirect & induced) – Typical Year	2,125 39 fewer than Proposed Action	2,113 51 fewer than Proposed Action	1,586 30 fewer than Proposed Action	1,568 48 fewer than Proposed Action

2.3.2.3.2 Proposed Kayenta Mine Complex

Table 2-18 provides estimates of reductions in coal mined at the Kayenta Mine under the Tribal PFR Alternative in relation to the Proposed Action. Less reduction in coal mining would occur than under the Natural Gas PFR Alternative because the renewable alternative energy source would not deliver as much energy to CAP, requiring more energy to be delivered from NGS. No modifications to the proposed KMC coal mining and handling equipment, mining procedures and reclamation, groundwater use, and waste disposal procedures would be required to implement the Tribal PFR Alternative. There would be a reduction in energy required to mine coal, and less surface disturbance from mining. On a proportional basis, these reductions would range from 2 to 7 percent less than under the Proposed Action operations.

Table 2-18 Annual Coal Mined for NGS Under for the Tribal PFR Alternative

NGS Configuration	Proposed Action	Tribal PFR 100-MW Reduction	Tribal PFR 250-MW Reduction
NGS – 3-Unit Operation			
Annual Coal Mined (in million tons)	8.1	7.9	7.7
Percentage Difference from Proposed Action [1]	NA	- 2%	- 5%
NGS – 2-Unit Operation			
Annual Coal Mined (in million tons)	5.5	5.3	5.1
Percentage Difference from Proposed Action [1]	NA	- 4%	- 7%

[1] Differences in tons of coal are relative to the base tonnages for the corresponding 3-Unit Operation or 2-Unit Operation under the Proposed Action.

Table 2-19 provides estimates of regional employment changes as the result of less coal mined under this PFR alternative. As indicated in the table, the greatest employment reductions would be associated with the 250-MW energy replacement operation under the 2-Unit NGS Operation.

Table 2-19 Regional Employment Associated with the Proposed KMC Under the Tribal PFR Alternative

	Regional Employment Numbers			
	3-Unit Operation NGS		2-Unit Operation NGS	
	Tribal 100-MW Reduction	Tribal 250-MW Reduction	Tribal 100-MW Reduction	Tribal 250-MW Reduction
Total Regional Jobs (direct indirect & induced) – Typical Year	1,618 30 fewer than Proposed Action	1,566 82 fewer than Proposed Action	1,095 134 fewer than Proposed Action	1,052 177 fewer than Proposed Action

Decommissioning and final reclamation for the proposed KMC would occur as described under the Proposed Action.

2.3.2.3.3 Transmission Systems and Communication Sites

For all PFR alternatives, the use, operation, maintenance and repair/replacement of the transmission systems and communication sites would be the same as described for the Proposed Action. Depending upon where the photovoltaic solar facility required for the Tribal PFR Alternative is located, additional transmission line(s) may need to be constructed to tie into the WTS or STS, which could require another federal action for acquisition of an additional ROW, if federal and tribal lands are involved. Minor modifications of a substation may be required in conjunction with the Tribal PFR Alternative, but no major modifications of the existing WTS and STS would be required.

2.3.3 No Action

2.3.3.1 Navajo Generating Station

Under the No Action Alternative, required federal approvals to extend the operations of the plant beyond December 23, 2019, would not be obtained. Decommissioning activities would begin in 2018 with effective shutdown of the plant occurring by the end of 2019. As provided in the 1969 Lease, if actions are not taken to extend NGS operations, the Lessees would be required to decommission NGS and associated facilities. The 1969 Lease requires that the "surface of any Reservation Lands modified or improved by the Lessees by the construction of access roads, dams, rail transportation facilities, surface pipelines, or other facilities constructed pursuant to this Lease or the [plant site] s 323 Grant" be restored as closely as possible to their original condition. Removal operations and all land surface restorations must be completed by the Lessees no later than December 22, 2020 (see 1969 Lease, Section 12).

The actions required for decommissioning of NGS and associated facilities under the No Action Alternative would be the same as those described under the Proposed Action (Section 2.3.1.1).

The NGS Co-tenants would need to obtain sufficient capacity and baseload energy to replace the amount lost due to the closure of NGS. Each Co-tenant would work independently to develop and secure its replacement resources. Current supply and demand projections for the region suggest that the predominant source of long-term replacement of baseload resources would eventually be the construction of new gas-fired, combined-cycle generation located at low elevations and near existing gas supply lines, transmission systems, water supplies, and the load areas of the Co-tenants. Because of the many variables that each utility would consider in its resource replacement strategy, including compliance and cost of environmental regulations such as the forthcoming ozone standards, it is not possible to accurately predict the location, number, or size of the replacement generating resources. Typically, a combined cycle gas-fired generating station would require a minimum of 4 years to over 6 years to plan, site, permit, and construct. In the interim, each utility would ensure sufficient baseload power resources for their customers through use of their existing generating resources, if available; the acquisition of existing merchant generation capacity; and power purchase agreements, or some combination of such resources. The ability to defer the construction of new replacement resources by utilizing existing resources would be dependent on regional peak capacity and demand conditions. It may be the case that limited excess peak capacity would exist and the construction of new resources would be expedited to ensure grid reliability.

The BM&LP Railroad would be decommissioned by removing the tracks and road bed, and then applying soil to the roadbed, and reseeding. The railroad embankment would not be modified, and would be allowed remain in accordance with the lease provisions (see Proposed Action).

2.3.3.2 Proposed Kayenta Mine Complex

The previously approved LOM plan for the Kayenta Mine would support mining operations through 2026 at the current production rate. However, the NGS presently is the sole commercial customer for the coal mined at the Kayenta Mine. Furthermore, the mine is distant from other existing coal-fired power plants, and those plants have established suppliers. Finally, the BM&LP Railroad that currently transports coal to NGS is not tied into the national rail network and, therefore, would be unable to serve as an initial link to ship coal to other markets. As a result, the potential for PWCC to find another market for its coal is low and the company has indicated it likely would move to close the proposed KMC and proceed to final reclamation of the Kayenta Mine and the former Black Mesa Mine and all support facilities not approved by OSMRE and the Navajo Nation as permanent facilities.

Mine closure and reclamation procedures would be the same as those described for the Proposed Action; however, mine closure and reclamation would take place pursuant to the existing Kayenta Mine permit, and would begin in 2018. Vegetation establishment and final bond release and lease relinquishment could take up to 10 to 15 years after reclamation is complete.

2.3.3.3 Transmission Systems and Communication Sites

The NGS transmission system is an established part of the western U.S. transmission grid and supports reliability and delivery of power throughout the region, well beyond the power generated by the NGS. Therefore, it is likely that that one, several, or all of the land owners/managers of the transmission line rights-of-way and communication site leases would renew some portion of the facilities to keep the power grid performing as expected. Currently, the authorization of the segments on non-tribal lands do not expire until 2022 or later. Additionally, portions of the transmission systems located on private lands have easements that have been granted in perpetuity.

To establish a baseline for comparing impacts against the Proposed Action for purposes of complying with NEPA, following is a description of a No Action Alternative that assumes the required federal approvals for the WTS and STS transmission systems, substations, and communication sites are not granted. All 275 miles of the WTS, 256 miles of the STS (two parallel transmission lines), three substation sites,[13] and two communication sites[14] would be decommissioned, removed, and sites reclaimed according to the land owner/manager's requirements. Decommissioning of these facilities would result in an estimated 4,826 acres of temporary disturbance, based on the following assumptions:

[13] Substations located within facilities shared with other utilities would not be removed nor the area reclaimed.

[14] For communication sites located within shared facilities, decommissioning would consist only of removal of the NGS-related communications equipment.

- Five transmission line tower structures per mile, or 3,935 structures for both the STS and WTS, would be removed. A workspace of one acre per structure would be required to allow large equipment to dismantle the structures, excavate foundations as necessary, and provide laydown areas. A total of 3,935 acres of disturbance would occur, based on these assumptions.
- Additional workspace would be required to remove and coil conductors. This requirement is assumed to be one acre per mile of transmission line, or 787 acres.
- Existing transmission line access roads would be used to the extent practical; however, widening the existing roads and expanding the road system may be required to allow passage of large trucks and equipment such as cranes. There would be a number of acres disturbed from road system expansion that cannot be estimated at this time.
- Nearly all communication sites are currently shared with other operators, and would not be decommissioned. Two communication sites (Zilnez and Glen Canyon) are not shared with others, but occupy less than 1 acre.
- Three STS substations (Yavapai, Cedar Mountain, Dugas) are not shared, and would be decommissioned. The facilities occupy 104 acres within the fence lines. No WTS substations would be decommissioned because they are shared with other operators.

It is likely that, where feasible, above-ground structures would be cut just below ground level and removed; flat areas would be re-contoured to match the natural grade, reseeded, and stabilized for revegetation. To reduce disturbance, subsurface structures would be left in place to the extent practicable. Additional temporary disturbance for reclamation of roads and any temporary storage areas also would occur.

Prior to any decommissioning, a major transmission interconnection study would be required to determine the effects of decommissioning the WTS and STS on the western electric grid, and whether, where, and what replacement facilities would be necessary. The currently unknown number of considerations that must be taken into account and amount of coordination that must occur with other utility and power providers to ensure reliability of the entire western U.S. transmission grid, make it impracticable to identify one or even a range of decommissioning scenarios that could be considered in this EIS in a meaningful way. A lengthy siting and permitting process and construction of replacement facilities prior to decommissioning would likely be required as a separate action.

2.3.3.4 Central Arizona Project

Under the No Action Alternative, NGS power and energy would no longer be available to operate the CAP pumps. As system operator, Central Arizona Water Conservation District would continue to be responsible for obtaining the power necessary to deliver CAP water. Central Arizona Water Conservation District has indicated that it intends to develop a diversified energy portfolio to manage risk and moderate impacts from energy market volatility, if and when NGS is no longer available. Central Arizona Water Conservation District has further indicated its goal is that no individual generation source or contractual supply would make up more than 15 to 20 percent of that portfolio (Central Arizona Water Conservation District 2013).

Under this alternative, Central Arizona Water Conservation District would acquire only enough energy to meet CAP pump loads. There would be no surplus power or energy that could be sold to create revenues for CAP repayment assistance.

Approximately 3.0 million MW-hours of electricity is needed annually to meet CAP pumping requirements (see **Appendix 2A**); this equates to an average hourly power requirement of about 350 MW, which Central Arizona Water Conservation District would meet through baseload resources. While coal, nuclear, and geothermal resources could provide baseload generation, it is anticipated that Central

Arizona Water Conservation District would look to natural gas-fueled generation to meet its baseload power needs for the following reasons:

- Coal. Construction of new coal-fired generation is highly unlikely due to environmental considerations, and it is anticipated that existing coal-fired generation (e.g., NGS) is already fully subscribed or is otherwise unavailable under this alternative.
- Nuclear. All existing nuclear power in the southwest is already fully subscribed, and new nuclear generation would take decades to permit and construct. Small modular reactor technology is under development, but is not anticipated to be commercially available by 2019.
- Geothermal. Geothermal resources are not commercially viable in Arizona (National Renewable Energy Laboratory 2012).
- Natural Gas. Combined Cycle Gas Turbines, could provide baseload generation for CAP. According to information supplied by USEPA in connection with its Clean Power Plan, the current capacity factor of Combined Cycle Gas Turbines located in Arizona is 27 percent. However, it appears that existing Combined Cycle Gas Turbine capacity is fully utilized in the summer months to meet Arizona's peak demands. It also is not clear how the closure of NGS would affect surplus Combined Cycle Gas Turbine capacity after 2019. So while there may be unused Combined Cycle Gas Turbine capacity that could supply a portion of CAP's needs, Central Arizona Water Conservation District may need to construct its own Combined Cycle Gas Turbine facility to obtain a baseload resource for summer months.

The most likely scenario would be one or more power purchase agreements to acquire baseload electrical power from the open market. Based on recent NREL predictions (NREL 2015d), power purchase costs would range from $37.70 to $51.60 per MWH between 2020 and 2025, climbing to between $46.10 and $65.10 per MWH between 2030 and 2044. On an annual basis those costs would translate to total annual energy costs of between $101.6 million and $139.1 million during the 2020 to 2025 time period and between $124.3 million and $175.5 million during the 2030 to 2044 time period. Over the 2020 to 2044 period, the range of energy costs assuming power purchase agreements ranges between $2.93 billion and $4.09 billion, depending on the future price of natural gas.

Central Arizona Water Conservation District may be able to use renewable resources (most likely photovoltaic solar) to supply a minor portion of its energy portfolio, but such resources cannot meet CAP's baseload need because renewable sources are intermittent.

The amount, intensity, and duration of ground disturbance and construction-related noise and traffic would be dependent upon the type of facility being constructed. **Table 2-20** provides some general assumptions of the land and infrastructure requirements needed for a new Combined Cycle Gas Turbine generation facility.

Table 2-20 Assumptions for 350-MW Combined Cycle Natural Gas Turbine Facility Land Requirements, Permitting, and Construction

Activity	Natural Gas Facility	Transmission Line Construction
Land acquisition/zoning/permitting/transmission impact study/contractor selection and award	4 years	6 years
Land clearing and leveling for facility/temporary ROW	60 acres	NA
Total footprint for permanent facility	50 acres	100-foot-wide ROW
Tie-in to existing substation/CAP transmission system (width)	100-foot-wide ROW	100-foot-wide ROW
Duration of construction	3 years	2-3 years

2.3.4 Impact Summary

Table 2-21 provides a summary of the primary environmental and social impacts identified for each resource for each alternative, and the level of impact, ranging from none to major. Impacts are expressed for the NGS-KMC Project as whole, which includes the NGS and associated facilities; BM&LP Railroad; Kayenta Mine, and the Southern and Western Transmission Systems. Impacts have been identified and classified for each project component separately in the resource sections. This table provides an overview of the range of impact levels for the entire project, and then identification of the most important findings. The impact findings included in this summary are derived from the project summaries for each alternative in the resource sections. Due to the nature and extent of the assumptions made to conduct the technical studies which were used to compare the impacts resulting from each alternative, the analyses provide more value as a comparison of each action alternative to the others and to the No Action Alternative's baseline, rather than as a prediction of actual changes that would occur for a particular resource area.

The primary focus of this tabular summary is on impacts that would occur from 2020 through 2044 from the Proposed Action, and how the three partial federal energy replacement alternatives would be similar, or different from the Proposed Action. The No Action summary provides an estimate of the environmental conditions if this project no longer operates after 2019, and begins a decommissioning phase.

A cumulative impact summary is presented for each resource and alternative. The discussion is centered on whether cumulative impacts are anticipated, and if so, the portion of the cumulative impacts contributed by the project, and then an estimate of the total cumulative impact and its importance.

Table 2-21 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.1 Air Quality	The project would be in compliance with national ambient air quality standards, and maximum impacts from both facilities primarily would occur near the sources and decrease with distance. Overall project air quality impacts from 2020 to 2044 (including regional haze and ozone) would be minor to moderate near NGS and the proposed KMC. Source emissions would be reduced by various controls, ranging from stack scrubbers at NGS to watering of haul roads for dust control at the proposed KMC. Deposition of selenium from the proposed KMC would be minor; all other deposition would be negligible. Short-term moderate increases in fugitive dust and equipment emissions would occur during decommissioning over a 1-year period at NGS and a minimum 10-year period at the proposed KMC starting in 2044. In the event some or all of the transmission systems and communication site ROWs (estimated at 4,826 acres) are	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Project compliance with air quality standards would be the same as the Proposed Action. Overall project air quality impacts from 2020 to 2044 (including regional haze and ozone) would be minor to moderate near NGS and the proposed KMC. Stack emissions from NGS would be 5 to 19 percent less, and proposed KMC surface disturbance would be 5 to18 percent less than the Proposed Action. Short-term minor increases in fugitive dust and equipment emissions would occur as described for the Proposed Action decommissioning. WTS and STS operations would continue as described for the Proposed Action. Cumulative impacts would be slightly less than for the Proposed Action, and dominated by non-project activities.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Project compliance with air quality standards would be the same as the Proposed Action. Overall project air quality impacts from 2020 to 2044 (including regional haze and ozone) would be minor to moderate near NGS and the proposed KMC. Stack emissions from NGS would be 3 to 11 percent less, and proposed KMC surface disturbance would be 3 to10 percent less than the Proposed Action. Short-term minor increases in fugitive dust and equipment emissions would occur as described for the Proposed Action decommissioning. WTS and STS operations would continue as described for the Proposed Action. Cumulative impacts would be slightly less than for the Proposed Action and dominated by non-project activities.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Air quality impacts would be analyzed in a subsequent NEPA action. Project compliance with air quality standards would be the same as the Proposed Action. Overall project air quality impacts from 2020 to 2044 (including regional haze and ozone) would be minor to moderate near NGS and the proposed KMC. Stack emissions from NGS would be 2 to 8 percent less, and proposed KMC surface disturbance would be 2 to 7 percent less than the Proposed Action. Short-term minor increases in fugitive dust and equipment emissions would occur as described for the Proposed Action decommissioning. WTS and STS operations would be as described for the Proposed Action. Cumulative impacts would be slightly less than for the	NGS stack emissions and Kayenta Mine mining activity emissions would cease in 2019. Air pollutant ground level concentrations would return to background levels. Short-term moderate increases in fugitive dust and equipment emissions would occur during decommissioning operations at both NGS (2018-2019) and the Kayenta Mine (over minimum 10-year period starting in 2019). The NGS transmission system is an established part of the western U.S. transmission grid and supports reliability and delivery of power throughout the region, beyond the power from NGS. Under the No Action Alternative, it is likely that that one, several, or all of the land owners/managers of the transmission line ROWs and communication site leases would renew all or part of the facilities to maintain expected power grid performance. In the event some or all of the transmission systems and communication site ROWs (estimated at 4,826 acres total) are not renewed, a lengthy

Table 2-21 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.1 Air Quality (continued)	not renewed/decommissioned, a lengthy study and permitting process, and construction of replacement facilities, would precede any decommissioning due to the essential and integral nature of these facilities with the western electric grid. Cumulative impacts regionally (within 300 km of NGS) would be major for ozone, and minor to major for acid deposition due to the additive effects of NGS and other sources. Maximum cumulative criteria pollutant impacts would be minor. Cumulative regional haze would be moderate.			Proposed Action and dominated by non-project activities.	study and permitting process, and construction of any replacement facilities, would precede any decommissioning due to the essential and integral nature of these facilities with the western electric grid.
3.2 Climate and Climate Change	Future Project greenhouse gas emissions are estimated to range between 18.4 (3-unit) and 12.3 (2-unit) million metric tons per year over the period 2020-2044. Over this time frame, it is estimated that global greenhouse gas emissions would increase 52 percent because of increased energy demands, a major [cumulative] impact. Because NGS-KMC Project's greenhouse emissions would be constant, they would represent a declining share of the overall global increase.	Future Project greenhouse gas emissions are estimated to range between 17.9 and 17.1 (3-unit) and 11.8 and 11.0 (2-unit) million metric tons per year over the period 2020-2044. These emissions represent a 12 to 30 percent greenhouse gas reduction relative to the Proposed Action because natural gas-generated energy purchased from the market would be substituted for coal combustion at NGS.	Future Project greenhouse gas emissions are estimated to range between 17.9 and 17.1 (3-unit) and 11.8 and 11.0 (2-unit) million metric tons per year over the period 2020-2044. These emissions represent a 12 to 30 percent greenhouse gas reduction relative to the Proposed Action because renewable source-generated energy purchased from the market would be substituted for coal combustion at NGS.	Future Project greenhouse gas emissions are estimated to range between 18.1 and 17.6 (3-unit) and 12.0 and 11.5 (2-unit) million metric tons per year over the period 2020-2044. These emissions represent an 8 to 19 percent greenhouse gas reduction relative to the Proposed Action because renewable energy, generated from a photovoltaic solar facility on tribal land, would be substituted for coal combustion at NGS.	After NGS and the Kayenta Mine cease operations in 2019 under the 1969 lease and other existing arrangements, it is assumed that federal share replacement power for the CAP system would be provided by a natural gas combined cycle source. On this basis, 8.6 metric tons of greenhouse gases would be emitted, or 53 percent less than the Proposed Action 3-unit operation, and 30 percent less than the Proposed Action 2-unit operation.

Table 2-21 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.3 Geology	NGS and proposed KMC components and operations would not impact unique geologic features and would be exposed to minor risk from damage during an earthquake event from 2020 through 2044. Mining at proposed KMC and coal combustion disposal would result in minor impact to land forms. The WTS and STS would continue operations as described under the Air Quality Proposed Action and no impacts to unique geologic resources are anticipated. The WTS would be at minor risk of damage from earthquakes because of its proximity to active faults and higher potential ground motion during an earthquake.	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Impacts to unique geologic resources, land forms, and as a result of geologic hazards would be the same as the Proposed Action, except that 5 to 18 percent less mining surface disturbance would occur at the proposed KMC, resulting in less impact to land forms.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Impacts to unique geologic resources, land forms, and as a result of geologic hazards would be the same as the Proposed Action, except that 3 to 10 percent less mining surface disturbance would occur at the proposed KMC, resulting in less impact to land forms.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Geology resource impacts would be analyzed in a subsequent NEPA action. Impacts to unique geologic resources, land forms, and as a result of geologic hazards would be the same as the Proposed Action, except that 2 to 7 percent less mining surface disturbance would occur at the proposed KMC, resulting in less impact to land forms.	Demolition and mine closure after 2019 would have no impact to unique geologic resources and negligible impacts to land forms as a result of reclamation activities. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative. The WTS would be at minor risk of damage from earthquakes because of its proximity to active faults and higher potential ground motion during an earthquake.
3.4 Minerals	Negligible project impacts to mineral resource availability because of the absence of known commercially extractable minerals except for coal at the proposed KMC. Coal resources at the proposed KMC would be adequate to meet NGS power generation commitments. The WTS and STS would	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Mineral resource occurrence and availability impacts would be the same as the Proposed Action, except that 5 to 18 percent less mining surface disturbance would occur at the proposed KMC.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Mineral resource occurrence and availability impacts would be the same as the Proposed Action, except that 3 to 10 percent less mining surface disturbance would occur at the proposed KMC.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Mineral resource impacts would be analyzed in a subsequent NEPA action. Mineral resource occurrence and availability impacts would be the same as the Proposed Action, except that 2 to 7	Negligible impacts on mineral resources from decommissioning at NGS, BM&LP Railroad, and the Kayenta Mine after 2019. Impacts as described in the Proposed Action would not occur because coal extraction from 5,230 to 4,741 acres at Kayenta Mine after 2019 would not occur.

Table 2-21 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.4 Minerals (continued)	continue operations as described under the Air Quality Proposed Action.			percent less mining surface disturbance would occur at the proposed KMC.	Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative.
3.5 Paleonto-logical	Negligible project surface disturbance impacts to fossil resources because of the generally low to moderate fossil importance rank of the bedrock formations, and the recommended unanticipated discovery protection measure at proposed KMC. The WTS and STS would continue operations as described under the Air Quality Proposed Action.	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Paleontological resource impacts would be the same as the Proposed Action, except that 5 to 18 percent less mining surface disturbance would occur at the proposed KMC.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Paleontological resource impacts would be the same as the Proposed Action, except that 3 to 10 percent less mining surface disturbance would occur at the proposed KMC.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Paleontological resource impacts would be analyzed in a subsequent NEPA action. Paleontological resource impacts would be the same as the Proposed Action, except that 2 to 7 percent less mining surface disturbance would occur at the proposed KMC.	Negligible impacts on paleontological resources from decommissioning NGS, BM&LP Railroad, and the Kayenta Mine after 2019. Impacts as described in the Proposed Action would not occur because coal extraction from 5,230 to 4,741 acres at Kayenta Mine after 2019 would not occur. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative.

Table 2-21 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.6 Soil	Moderate project soil surface disturbance impacts from 2020 to 2044 would range from 4,998 to 5,527 acres. Soils and suitable revegetation material would be salvaged and protected in accordance with federal regulatory programs and lease terms. Minor trace metal deposition impacts. Predicted trace metal deposition would not cause applicable EPA soil screening levels to be exceeded or contribute to unacceptable human or ecological risks. After 2044, 10,123 acres on NGS, the BM&LP Railroad, and the proposed KMC would require reapplication of soil or suitable revegetation materials and seeded. The WTS and STS would continue operations as described under the Air Quality Proposed Action. Proposed Action contributes 7 to 8 percent to estimated cumulative soil disturbance of 61,985 to 62,514 acres, a moderate cumulative impact.	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate project soil disturbance impacts from 2020 to 2044 would be 5 to 18 percent less than the Proposed Action because less coal would be mined. Minor trace metal deposition impacts would be 5 to 19 percent less than the Proposed Action. Decommissioning after 2044 also would be proportionally less. Cumulative impacts slightly less than Proposed Action.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate project soil disturbance impacts from 2020 to 2044 would be 3 to 10 percent less than the Proposed Action because less coal would be mined. Minor trace metal deposition would be 2 to 12 percent less than the Proposed Action. Decommissioning after 2044 also would be proportionally less. Cumulative impacts slightly less than Proposed Action.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Soil resource impacts would be analyzed in a subsequent NEPA action. Moderate project soil disturbance impacts from 2020 to 2044 would be 2 to 7 percent less than the Proposed Action because less coal would be mined. Minor trace metal deposition impacts would be 2 to 11 percent less than the Proposed Action. Decommissioning after 2044 also would be proportionally less. Cumulative impacts slightly less than Proposed Action.	Demolition and mine closure after 2019 would require topsoiling and seeding on 9,272 acres. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative. Soil protection, and erosion and sediment control programs, and transmission line and communication site operation and maintenance activities would be the same as those described for the Proposed Action. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative.

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Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.7 Water	Moderate to negligible project impacts from 2020 to 2056 to surface water and groundwater water quantity and quality. Moderate impacts include modifications in surface flows in major washes downstream from the proposed KMC caused by changes in location and capacity of storage ponds. Minor project impacts include mine pumping drawdown of N-Aquifer utilized by nearby community wells, increases in community well pumping costs; and changes in water levels in the Wepo aquifer that may affect community surface water uses, and water quality. The Project is projected to contribute minor reductions in future N-Aquifer drawdown, but cumulative drawdown from all sources is predicted to be major (see No Action). The WTS and STS would continue operations as described under the Air Quality Proposed Action.	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate and minor project impacts from 2020 to 2044 would be the same as the Proposed Action except that 5 to 18 percent less mining surface disturbance would occur at the proposed KMC, which may modify plans for stormwater retention. Proposed KMC groundwater pumping demands would remain the same. Cumulative impacts would be similar to the Proposed Action.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate and minor project impacts from 2020 to 2044 would be the same as the Proposed Action except that 3 to 10 percent less mining surface disturbance would occur at the proposed KMC, which may modify plans for stormwater retention. Proposed KMC groundwater pumping demands would remain the same. Cumulative impacts would be similar to the Proposed Action.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Water resource impacts would be analyzed in a subsequent NEPA action. Moderate and minor project impacts from 2020 to 2044 would be the same as the Proposed Action except that 2 to 7 percent less mining surface disturbance would occur at the proposed KMC, which may modify plans for stormwater retention. Proposed KMC groundwater pumping demands would remain the same. Cumulative impacts would be similar to the Proposed Action.	By ceasing Kayenta Mine operations in 2019, mine drawdown impacts on nearby community wells and pumping costs would be negligible. Major to moderate N-Aquifer water level impacts are predicted as the result of community pumping through 2057 when up to 150 feet of drawdown is predicted. Major baseflow declines in Chinle Creek, Laguna Creek, and Polacca Wash would largely result from projected community pumping. Simulated reductions in flow at both monitored and non-monitored springs also are predicted to result from increases in community pumping over time. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative.

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Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.8 Vegetation	Moderate to negligible project impacts on vegetation. Moderate project vegetation removal impacts from 2020 to 2044 would range from 4,998 to 5,527 acres. Disturbed areas would be reseeded with approved mixtures, and monitored for release back to the Navajo Nation and Hopi Tribe. Re-establishment of grassland communities would require 5 years; shrublands and woodlands from 25 to 50 years. Minor project impacts from noxious weeds which could quickly expand across disturbed areas. Weed populations would be targets of ongoing control during reclamation. After 2044, 10,123 acres of project surface disturbance would require reapplication of soil followed by reseeding, and approved for release to the land owner. The WTS and STS would continue operations as described under the Air Quality Proposed Action. Project vegetation removal	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate project vegetation removal impacts from 2020 to 2044 would be 5 to 18 percent less than the Proposed Action because less coal would be mined; decommissioning requirements also would be proportionally less. Moderate cumulative vegetation removal impacts would be slightly less than the Proposed Action because of less surface disturbance on the proposed KMC.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate project vegetation removal impacts from 2020 to 2044 would be 3 to 10 percent less than the Proposed Action because less coal would be mined; decommissioning requirements after 2044 would be proportionally less. Moderate cumulative vegetation removal impacts would be slightly less than the Proposed Action because of less surface disturbance on the proposed KMC.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Vegetation resource impacts would be analyzed in a subsequent NEPA action. Moderate project vegetation removal impacts from 2020 to 2044 would be 2 to 7 percent less than the Proposed Action because less coal would be mined; decommissioning requirements after 2044 also would be proportionally less. Moderate cumulative vegetation removal impacts would be slightly less than the Proposed Action because of less surface disturbance on the proposed KMC.	Demolition and mine closure after 2019 would require seeding on 9,272 acres. Seeding requirements would be the same as those for the Proposed Action. Negligible impacts to native riparian communities in major washes near Kayenta Mine from community pumping because of predicted reductions in baseflows, Primary areas of concern are Chinle Creek, Laguna Creek, and Polacca Wash, where native riparian vegetation communities are not present, or are extremely small and isolated. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative.

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Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.8 Vegetation (continued)	impacts from 2020-2044 would contribute 7 to 8 percent of up to 61,985 to 62,514 acres of moderate cumulative vegetation removal impacts.				
3.9 Special Status Vegetation Resources	Negligible project impacts on special status plants. Negligible potential surface disturbance impacts to special status plants from O&M activities in transmission line ROW; negligible loss of special status plants and populations from project new surface disturbance, and N-Aquifer drawdown. The WTS and STS would continue operations as described under the Air Quality Proposed Action. Minor cumulative risks for loss of special status plants from foreseeable utility construction activities adjacent to, or near the WTS ROW.	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Negligible project impacts on special status plants. Minor cumulative risks for loss of special status plants from foreseeable utility construction activities adjacent to, or near the WTS ROW.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Negligible project impacts on special status plants. Minor cumulative risks for loss of special status plants from foreseeable utility construction activities adjacent to, or near the WTS ROW.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Special status vegetation impacts would be analyzed in a subsequent NEPA action. Negligible project impacts on special status plants. Minor cumulative risks for loss of special status plants from foreseeable utility construction activities adjacent to, or near the WTS ROW.	Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative. O&M activities would occur along transmission line access roads, and periodic repairs may be required. Negligible risk of special status plant disturbance.
3.10 Terrestrial Wildlife	Moderate to negligible impacts to wildlife habitat and populations. Moderate impacts on wildlife habitat from vegetation removal; moderate impacts from direct losses of individuals from collisions, and electrocution; habitat avoidance impacts from human activities	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate habitat removal impacts from 2020 to 2044 would be 5 to 18 percent less than the Proposed Action	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate habitat removal impacts from 2020 to 2044 would be 3 to 10 percent less than the Proposed Action	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Terrestrial wildlife impacts would be analyzed in a subsequent NEPA action. Moderate habitat removal	From 4,998 to 5,527 acres of shrubland and woodland vegetation at NGS and Kayenta Mine would not be removed by coal mining. Impacts to the WTS and STS are the same as described for the Air Quality No Action

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Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.10 Terrestrial Wildlife (continued)	at the proposed KMC (traffic, lighting, noise). The WTS and STS would continue operations as described under the Air Quality Proposed Action. Moderate cumulative impacts due to regional habitat removal, foreseeable construction near the WTS.	because less coal would be mined. Direct animal losses and human activity levels would be the same as the Proposed Action. Moderate cumulative impacts would be slightly less than the Proposed Action because of reduced mining surface disturbance (see Vegetation).	because less coal would be mined. Direct animal losses and human activity levels would be the same as the Proposed Action. Moderate cumulative impacts would be slightly less than the Proposed Action because of reduce mining surface disturbance (see Vegetation).	impacts from 2020 to 2044 would be 2 to 7 percent less than the Proposed Action because less coal would be mined. Direct animal losses and human activity levels would be the same as the Proposed Action. Moderate cumulative impacts would be slightly less than the Proposed Action because of reduce mining surface disturbance (see Vegetation).	Alternative.
3.11 Special Status Wildlife Resources	Minor project impacts to individuals of the Mexican spotted owl from mining-related noise and lighting; minor impacts to Mojave and Sonoran desert tortoise from vehicle collisions during WTS and STS O&M activities. The WTS and STS would continue operations as described under the Air Quality Proposed Action. Cumulative effects minor to moderate on Mojave desert tortoise, southwest willow flycatcher, and yellow-billed cuckoo due to foreseeable transmission line and water pipeline construction.	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Minor project impacts to special status species, same as Proposed Action. Cumulative impacts to the Mexican Spotted Owl, Mojave Desert Tortoise, Southwestern Willow Flycatcher, and yellow-billed Cuckoo would be same as the Proposed Action.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Minor project impacts to special status species, same as Proposed Action. Cumulative impacts to the Mexican Spotted Owl, Mojave Desert Tortoise, Southwestern Willow Flycatcher, and yellow-billed Cuckoo would be same as the Proposed Action.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Special status wildlife impacts would be analyzed in a subsequent NEPA action. Minor project impacts to special status species, same as Proposed Action. Cumulative impacts to the Mexican Spotted Owl, Mojave Desert Tortoise, Southwestern Willow Flycatcher, and yellow-billed Cuckoo would be same as the Proposed Action.	From 4,998 to 5,527 acres of shrubland and woodland vegetation at NGS and Kayenta mine would not be removed by coal mining, resulting in lower human activity impacts on the Mexican spotted owl. Vehicle collisions risk for Mojave and Sonoran Desert Tortoise would be same because foreseeable construction projects adjacent to the WTS would likely occur; Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative. O&M activities along the WTS and STS would continue, unless full decommissioning occurs.

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Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.12 Aquatic Biological Resources	Minor to negligible NGS trace metal deposition impacts on aquatic community constituents and water quality. The combination of baseline concentrations with very small project contributions would result in a minor risk of selenium effects on fish populations in the San Juan River and the Colorado River below Glen Canyon Dam. Minor impacts to aquatic species due to elevated metals concentrations that exceed toxicity thresholds in proposed KMC surface waterbodies, primarily from background sources. Groundwater pumping for the proposed KMC Proposed Action would contribute less than 1 percent reduction in Begashibito Wash, resulting in minor changes in aquatic habitat where surface flows are present. The WTS and STS would continue operations as described under the Air Quality Proposed Action. NGS future operations would	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. NGS trace metal impacts would be the same as the Proposed Action, except NGS stack emissions would be 5 to 19 percent less. Cumulative impacts from trace metals deposition, and cumulative groundwater pumping impacts on aquatic habitats would be the same as the Proposed Action.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. NGS trace metal impacts on fisheries would be the same as the Proposed Action, except NGS stack emissions would be 3 to 11 percent less. Cumulative impacts from trace metals deposition, and cumulative groundwater pumping impacts on aquatic habitats would be the same as the Proposed Action.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Aquatic biological resource impacts would be analyzed in a subsequent NEPA action. NGS trace metal impacts on fisheries would be the same as the Proposed Action, except NGS stack emissions would be 2 to 8 percent less. Cumulative impacts from trace metals deposition, and cumulative groundwater pumping impacts on aquatic habitats would be the same as the Proposed Action.	The elimination of current NGS emissions would subtract a very small emission level from existing baseline conditions. There would be continued minor deposition impacts from mercury and selenium in the Colorado River below Glen Canyon Dam, and selenium in the San Juan River on some nongame fish species. Because the elimination of emission effects from the proposed KMC facilities would be very small, the resulting metal concentrations in waterbodies would be negligible. Continued minor impacts to aquatic species due to elevated metals concentrations that exceed toxicity thresholds in Kayenta Mine surface waterbodies, primarily from background sources. Community pumping would result in base flow reductions of approximately 8 to 22 percent in Polacca, Chinle, and Begashibito washes and Laguna Creek, which would cause moderate reductions in aquatic habitat and aquatic invertebrates where surface water is present. Impacts to the WTS and STS

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Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.12 Aquatic Biological Resources (continued)	contribute a small fraction of the total cumulative fish tissue concentrations. Cumulative deposition of mercury and selenium in the Colorado River below Glen Canyon Dam and in the San Juan River present a potential risk to fish populations. Global and other regional sources are the main contributors to metal effects.				are the same as described for the Air Quality No Action Alternative.
3.13 Special Status Aquatic Biological Species	Minor trace metal deposition impacts based on the low number of fish that could be injured and the small percentage of fish population numbers potentially affected. Minor project impacts (measured by tissue concentrations) to fish individuals of Colorado pike minnow, razorback sucker, and humpback chub from NGS trace metal contributions combined with baseline concentrations. Minor impacts on critical habitat for Colorado pikeminnow and razorback sucker in the San Juan River and humpback chub and razorback sucker in the Colorado River below Glen Canyon Dam, because of historical small baseline exceedances of mercury and selenium water quality	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. NGS trace metal impacts would be the same as the Proposed Action, except NGS stack emissions would be 5 to19 percent less. Cumulative impacts from trace metals deposition would be nearly the same as the Proposed Action.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. NGS trace metal impacts would be the same as the Proposed Action, except NGS stack emissions would be 3 to 11 percent less. Cumulative impacts from trace metals deposition would be nearly the same as the Proposed Action.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Special status aquatic biological resource impacts would be analyzed in a subsequent NEPA action. NGS trace metal impacts would be the same as the Proposed Action, except NGS stack emissions would be 2 to 8 percent less. Cumulative impacts from trace metals deposition would be nearly the same as the Proposed Action.	Elimination of current NGS emissions after 2019 would subtract a very small emission level from existing baseline conditions. Potential risks to special status species would occur in the Colorado River below Glen Canyon Dam and San Juan River due to baseline fish tissue concentrations. There would be a minor effect on the water element of critical habitat for humpback chub and razorback sucker in the Colorado River below Glen Canyon Dam and Colorado pikeminnow and razorback sucker in the San Juan River, based on historical exceedances of mercury or selenium water quality standards. Impacts to the WTS and STS are the same as described for the Air Quality No Action

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Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.13 Special Status Aquatic Biological Species (continued)	standards. The WTS and STS would continue operations as described under the Air Quality Proposed Action. Minor cumulative impacts (based on life stage injury estimates) of mercury to individuals of Colorado pikeminnow in the San Juan River; moderate impacts of mercury on humpback chub individuals and critical habitat in the Colorado River below Glen Canyon Dam; moderate impacts to razorback sucker individuals and critical habitat in the Colorado River below Glen Canyon Dam and in the San Juan River. Project emissions contributions to mercury concentrations in fish tissue are estimated to be 0.1 to 0.2 percent.				Alternative.
3.14 Land Use	Moderate project land use impacts, almost entirely from continued mining on proposed KMC. Vegetation removal impacts from 2020 to 2044 would range from 4,998 to 5,527 acres. Area of surface disturbance requiring reclamation after 2044 is 10,123 acres. Disturbed areas would be reseeded with	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate project land use impacts would be the same as the Proposed Action except that 5 to 18 percent less surface disturbance at the	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Moderate project land use impacts would be the same as the Proposed Action except that 3 to 10 percent less surface disturbance at the	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Land use impacts would be analyzed in a subsequent NEPA action. Moderate project land use impacts would be the same as	From 4,998 to 5,527 acres of shrubland and woodland vegetation at NGS and Kayenta Mine would not be removed by coal mining, and would be available for grazing and other uses. Once decommissioning and reclamation activities are complete after 2019, the NGS site, BM&LP Railroad ROW, and Kayenta Mine would be

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Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.14 Land Use (continued)	approved mixtures, and monitored for release back to the Navajo Nation and Hopi Tribe. Incremental reduction or removal of four to five grazing areas would reduce livestock grazing capacity. Residential relocations from mining areas would be a moderate impact because the residents are compensated.	proposed KMC would occur because less coal would be mined, which may change number of residents that would require relocation.	proposed KMC would occur because less coal would be mined, which may change number of residents that would require relocation.	the Proposed Action except that 2 to 7 percent less surface disturbance at the proposed KMC would occur because less coal would be mined, which may change number of residents that would require relocation.	returned to the Navajo Nation and Hopi Tribe. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative.
3.15 Public Safety	Minor to negligible project public safety impacts because the public is excluded from the industrial activity areas of the NGS and the proposed KMC. Residents within the proposed KMC lease boundary would be exposed to equipment noise, periodic blasting, mine traffic, and potential hazardous spills Planning and implementation of best management practices would reduce impacts from potential spills. Notice of blasting activity is provided in advance and residential relocation programs are initiated when mining encroaches within the safety zone around residences. The WTS and STS would continue operations as described under the	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Minor to negligible project public safety impacts would be the same as the Proposed Action except that 5 to 18 percent less surface disturbance at proposed KMC would occur because less coal would be mined, which may change the number of residents that would require relocation, and change the residence exposure distance to potential spills, noise and fugitive dust sources.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Minor to negligible project public safety impacts would be the same as the Proposed Action except that 3 to 10 percent less surface disturbance at proposed KMC would occur because less coal would be mined, which may change the number of residents that would require relocation, and change the residence exposure distance to potential spills, noise and fugitive dust sources.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Public safety impacts would be analyzed in a subsequent NEPA action. Minor to negligible project public safety impacts would be the same as the Proposed Action except that 2 to 7 percent less surface disturbance at proposed KMC would occur because less coal would be mined, which may change the number of residents that would require relocation, and change the residence exposure distance to potential spills, noise and fugitive dust sources.	Mine reclamation activities would continue after 2019, but no active surface mining. Residential relocations, noise disturbance, and other impacts as described in the Proposed Action and action alternatives in the proposed mining areas would not occur.

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Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.15 Public Safety (continued)	Air Quality Proposed Action.				
3.16 Public Health and Human Health Risk	Human health risks from project component emissions are negligible because potential cancer and non-cancer risks are considered acceptable based on human health risk assessments. Project operations would result in minor or negligible health impacts to the general population. Major project benefits to public health result from long-term employment at NGS and the proposed KMC and opportunities for health care. These benefits are offset by minor emotional stress caused by relocation of residents and the indirect health effects associated with proximity to mining noise and equipment activity. The WTS and STS would continue operations as described under the Air Quality Proposed Action. Based on an unacceptable non-cancer hazard of 2 for the ingestion of Lake Powell fish by the recreational user, a minor	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Negligible project human health risks and minor to negligible health impacts would be the same as the Proposed Action except that 5 to 18 percent less surface disturbance would occur because of less coal mining, resulting in less exposure to fugitive dust over the long term. Minor Lake Powell fish ingestion hazards would be the same as the Proposed Action.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Negligible project human health risks and minor to negligible health impacts would be the same as the Proposed Action except that 3 to 10 percent less surface disturbance would occur because of less coal mining, resulting in less exposure to fugitive dust over the long term. Minor Lake Powell fish ingestion hazards would be the same as the Proposed Action.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Impacts to public health and human health risks would be analyzed in a subsequent NEPA action. Negligible project human health risks and minor to negligible health impacts would be the same as the Proposed Action except that 2 to 7 percent less surface disturbance would occur because of less coal mining, resulting in less exposure to fugitive dust over the long term. Minor Lake Powell fish ingestion hazards would be the same as the Proposed Action.	Human exposure to NGS stack emissions would cease after 2019. Dust emissions from decommissioning and reclamation activities at NGS would occur over a 1-year period, and over a minimum of 10 years at the Kayenta Mine, a negligible human health impact. Closure of the Kayenta Mine after 2019 would eliminate public exposure to mine traffic, equipment noise, and blasting. The loss of jobs at both NGS and the Kayenta Mine would result in increased stress for unemployed workers and their families and potential loss of health benefits. This constitutes a major impact on public health. Minor Lake Powell fish ingestion hazards would be the same as the Proposed Action. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative.

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Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.16 Public Health and Human Health Risk (continued)	impact on human health was identified. The impact is considered minor because of the fish advisory (Arizona Game and Fish Department 2012) that likely limits the consumption of fish. NGS trace metal contributions to this hazard would be negligible.				
3.17 Cultural Resources	Major to negligible impacts to cultural resources from surface mining at the proposed KMC. Moderate to major impacts from discovery and repatriation of human burials within areas to be mined; moderate impacts to archeological and architectural sites; negligible to major impacts to Traditional Cultural Properties, which are places important for traditional uses or religious values. Cultural resources potentially directly affected consist of 195 to 214 archaeological sites. 15 Traditional Cultural Properties; and 13 human remains. Two Programmatic Agreements developed for the NGS-KMC Project address cultural resource impacts for all project components and direct the responsible federal agencies to consult with federal, state, Tribal, municipal, and private landowners to address Section	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Major to negligible impacts to cultural resources from surface mining at proposed KMC. Direct impacts to cultural resources would be similar to the Proposed Action, but cannot be quantified because specific future mining plans have not yet been developed. Negligible to major cumulative risks for cultural resource disturbance from foreseeable utility construction activities adjacent to, or near the WTS ROW.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Major to negligible impacts to cultural resources from surface mining at the proposed KMC. Direct impacts to cultural resources would be similar to the Proposed Action, but cannot be quantified because specific future mining plans have not yet been developed. Negligible to major cumulative risks for cultural resource disturbance from foreseeable utility construction activities adjacent to, or near the WTS ROW.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Cultural resource impacts would be analyzed in a subsequent NEPA action. Major to negligible impacts to cultural resources from surface mining at the proposed KMC. Direct impacts to cultural resources would be similar to the Proposed Action, but cannot be quantified because specific future mining plans have not yet been developed. Negligible to major cumulative risks for cultural resource disturbance from foreseeable utility construction activities adjacent to, or near the WTS ROW.	Project impacts to historic properties listed in or potentially eligible for listing in the NRHP would not occur. Potential impacts to cultural resources of any type would take place during the decommissioning phase of the project. Any future undertakings, such as decommissioning and reclamation, would be addressed through the standard regulatory process (36 CFR 800) by the appropriate federal agency. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative.

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Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.17 Cultural Resources (continued)	106 requirements. The WTS and STS would continue operations as described under the Air Quality Proposed Action. Negligible to major cumulative risks for cultural resource disturbance from foreseeable utility construction activities adjacent to or near the WTS ROW.				
3.18 Socio-economics	Major economic impacts are associated with the continuation of the NGS-KMC Project. These include providing 2,745 to 3,812 jobs, approximately 187 to 260 million dollars in labor income, and estimated project-related payments to tribes of 1.8 to 2.5 billion over the 25-year period. A continued employment base would provide long-term social stability, and allow the younger generation members to remain in their communities. Concerns about the long-term commitment to coal as a source of electrical energy, public health, water supply availability, residential relocations, and grazing land availability would	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Major economic impacts are associated with continuation of the NGS-KMC Project. NGS and proposed KMC employment and labor income would be between 4 and 10 percent lower compared to the Proposed Action. These labor income and employment reductions would be major impacts because of the lack of revenue replacement opportunities. Project operations would provide long-term social stability, and concerns about commitment to coal as an	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Major economic impacts are associated with continuation of the NGS-KMC Project. NGS and proposed KMC employment and labor income would be between 3 and 6 percent lower compared to the Proposed Action. These labor income and employment reductions would be major impacts because of the lack of revenue replacement opportunities. Project operations would provide long-term social stability, and concerns about commitment to coal as an	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Socioeconomic impacts would be analyzed in a subsequent NEPA action. Major economic impacts are associated with continuation of the NGS-KMC Project. NGS employment and labor income would be between 3 and 7 percent lower compared to the Proposed Action. These labor income and employment reductions would be major impacts because of the lack of revenue replacement opportunities. Short-term employment (1 to 3 years) providing 550 to 650 construction jobs would provide	Major economic and social impacts would occur if NGS and the Kayenta Mine ceased operations after 2019. It is estimated that 3,090 jobs would be immediately lost, with a reduction in labor income of $234 million per year, as well as long-term retirement and pension income. Community contributions and scholarships provided by NGS and Kayenta Mine operators of approximately $700,000 per year; payments to the Navajo electrical utility; and PWCC contributions to abandoned mine and black lung funds would cease. Fiscal impacts would be major because of the very large contribution of NGS and the

Table 2-21 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.18 Socio-economics (continued)	continue. The WTS and STS would continue operations as described under the Air Quality Proposed Action. Pumping energy costs to CAP are expected to increase by 20 to 23 percent, as compared to 2016 base rate of $76 per acre-foot of water delivered (Agricultural Settlement Pool). This increase is considered a minor to moderate impact to agricultural water users. The contributions of the project to cumulative socioeconomic effects would be moderate to major because the incomes for residents and payments to the Navajo Nation and Hopi are substantial and would provide a measure of revenue stability at a time when revenues from other sources may decline.	energy source, and impacts to public health and land use would continue. Pumping energy costs to CAP would increase by between 45 and 112 percent as compared to 2016 base rate of $76 per acre-foot of water delivered (Agricultural Settlement Pool). This increase is considered a moderate to major impact to users. The contributions of the project to cumulative socioeconomic impacts would be moderate to major, same as the Proposed Action.	energy source, and impacts to public health and land use would continue. Pumping energy costs to CAP would increase by between 36 and 68 percent as compared to 2016 base rate of $76 per acre-foot of water (Agricultural Settlement Pool). This increase is considered a minor to major impact to users. The contributions of the project to cumulative socioeconomic impacts would be moderate to major, same as the Proposed Action.	a minor income and employment benefit. Project operations would provide long-term social stability, and concerns about commitment to coal as an energy source, and impacts to public health, cultural resources, and land use would continue. Pumping energy costs to CAP would increase by between 36 and 68 percent as compared to 2016 base rate of $76 per acre-foot of water delivered (Agricultural Settlement Pool). This increase is considered a minor to major impact to users. The contributions of the project to cumulative socioeconomic impacts would be moderate to major, same as the Proposed Action.	Kayenta Mine to the Navajo and Hopi government revenues, and the high proportion of tribal workers at both facilities. Rising unemployment would likely require many workers and their families to leave Page, Kayenta, and other nearby Navajo chapters for employment opportunities elsewhere. Economic hardship for local business would likely increase from the loss of power plant and mine employment. Project-related concerns about public health, cultural resources, and land use would diminish. Pumping energy costs to CAP could result in energy costs between 19 percent lower and 18 percent more costly as compared to 2016 base rate of $76 per acre-foot of water delivered (Agricultural Settlement Pool). This range is largely dictated by changes in natural gas prices. Costs of agricultural production may increase, resulting in less income to farmers. No excess generation income would be provided by NGS, and therefore

Table 2-21 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.18 Socio-economics (continued)					no contributions to the Development Fund. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative.
3.19 Environmental Justice	Residents living within and immediately adjacent to the proposed KMC who are part of the Environmental Justice population on the Navajo Nation would experience disproportionately high sociocultural impacts and minor to moderate human health impacts. No disproportionately high and adverse sociocultural or human health impacts to any other environmental justice populations would be anticipated. The WTS and STS would continue operations as described under the Air Quality Proposed Action. No disproportionately high and adverse air quality, water resources, ecological, or safety impacts to any environmental justice population would be anticipated.	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Environmental justice impacts would be the same as the Proposed Action.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Environmental justice impacts would be the same as the Proposed Action.	The Tribal PFR Alternative assumes a new, but unidentified site between 3,000 and 1,200 acres on tribal lands. Environmental Justice issues would be analyzed in a subsequent NEPA action. Environmental justice impacts would be the same as the Proposed Action.	Major economic and social impacts including the loss of over 3,000 total jobs, many of which are currently held by Navajo and Hopi workers. The loss of revenues from NGS and the Kayenta Mine to the Navajo Nation and Hopi Tribe would reduce services and employment on the two reservations that would represent a major, long-term impact for the two tribes. Employment losses would have corresponding social effects and potentially result in relocation for affected Navajo and Hopi families or wage earners. These economic and social impacts would be considered major, and they would accrue disproportionately to the Navajo Nation and Hopi Tribe, which are environmental justice populations identified for this EIS.

Table 2-21 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.20 Indian Trust Assets	Minor to negligible impacts would be anticipated to Navajo Nation and Hopi Tribe Indian trust assets. The impacts on land, water, and mineral trust assets would be offset by the negotiated compensations and protection measures provided by lease and ROW agreements, environmental regulations, plans, and programs (e.g., Coal Combustion Residuals Rule, Groundwater Protection Plan), No impacts to land trust assets of the Kaibab Band of Paiute Indians or Moapa Band of Paiute Indians related to the transmission systems and communication sites. The WTS and STS would continue operations as described under the Air Quality Proposed Action. No impact on water rights trust assets for the CAP-affected tribes. Higher energy costs for pumping CAP water and associated effects of higher costs on deposits to the Development Fund could affect economics of CAP water utilization for some CAP-	The Natural Gas PFR Alternative assumes no new site disturbance compared to the Proposed Action. Project impacts on Indian trust assets for the Navajo Nation, Hopi Tribe, Kaibab Band of Paiute Indians, and Moapa Band of Paiute Indians would be the same as the Proposed Action. No impact on water rights Indian trust assets for the CAP-affected tribes (same as the Proposed Action). Pumping energy costs could be higher or lower than those under the Proposed Action, depending on the future price of natural gas. This potentially could affect deposits to the Development Fund and the economics of CAP water utilization for some CAP-affected tribes.	The Renewable PFR Alternative assumes no new site disturbance compared to the Proposed Action. Project impacts on Indian trust assets for the Navajo Nation, Hopi Tribe, Kaibab Band of Paiute Indians, and Moapa Band of Paiute Indians would be the same as the Proposed Action. No impact on water rights Indian trust assets for the CAP-affected tribes (same as the Proposed Action). Pumping energy costs would be higher than those under the Proposed Action, depending on the future price of natural gas. This potentially could affect deposits to the Development Fund and the economics of CAP water utilization for some CAP-affected tribes.	The Tribal PFR Alternative assumes a new, but unidentified site(s) between 3,000 and 1,200 acres on tribal lands. The affected tribe would receive financial compensation and could negotiate for other measures to address impacts on Indian trust assets. Site-specific impacts on Indian trust assets would be analyzed in a subsequent NEPA action. Project impacts of NGS, the proposed KMC, transmission systems, and communications sites on Indian trust assets for the Navajo Nation, Hopi Tribe, Kaibab Band of Paiute Indians, and Moapa Band of Paiute Indians would be the same as the Proposed Action. No impact on water rights Indian trust assets for the CAP-affected tribes (same as the Proposed Action). Pumping energy costs would be higher than those under the Proposed Action, potentially affecting deposits to the Development Fund and the economics of CAP water utilization for some CAP-affected tribes.	No negative impacts to Indian trust assets of the Navajo Nation or Hopi Tribe would be anticipated. However, payments from 2020 to 2044 from NGS (totaling $793 million to $1.07 billion to the Navajo Nation) and from the proposed KMC (combined total to the Navajo Nation and Hopi Tribe from $787 million to $1.16 billion) for the use of water, land, and mineral Indian trust assets would be foregone compared to the Proposed Action. Impacts to the WTS and STS are the same as described for the Air Quality No Action Alternative. No impacts from continued operations and maintenance of the WTS, STS, and communications sites to Indian trust land assets of the Kaibab Band of Paiute Indians or Moapa Band of Paiute Indians. No impact on water rights Indian trust assets for the CAP-affected tribes (same as the Proposed Action). Pumping energy costs for CAP

Table 2-21 Navajo Generating Station – Kayenta Mine Complex Project Impact Summary

Resource\ Alternative	Proposed Action	Natural Gas PFR	Renewable PFR	Tribal PFR	No Action
3.20 Indian Trust Assets (continued)	affected tribes.				water under No Action could result in energy costs of between 23 percent lower and 21 percent higher than under the Proposed Action, depending on the future price of natural gas. Deposits into the Development Fund would cease. The effects could affect the economics of CAP water utilization for some CAP-affected tribes.

2.4 References

Bureau of Land Management (BLM). 2012. Final Programmatic Environmental Impact Statement (EIS) for Solar Energy Development in Six Southwestern States. Internet website: http://solareis.anl.gov/documents/fpeis/index.cfm. Accessed May 17, 2016.

Central Arizona Water Conservation District. 2013. Central Arizona Project, 2014-2015 Biennial Budget. Internet website: http://www.cap-az.com . Accessed October 2014.

Interstate Natural Gas Association of America (INGAA) Foundation, Inc. 2014. North American Midstream Infrastructure through 2035: Capitalizing on Our Energy Abundance. An INGAA Foundation Report, Prepared by ICF International. Executive Summary, March 18, 2014.

National Renewable Energy Laboratory. 2015a. Cost Estimates for Screened Alternatives for the Navajo Generating Station/Kayenta Mining Complex Environmental Impact Statement – Technical Memorandum from D. Hurlbut and M. Day (NREL) to R. Callejo, U.S. Bureau of Reclamation. January 6, 2015.

National Renewable Energy Laboratory. 2015b. Mead Wholesale Energy Market and Natural Gas Prices – Technical Memorandum from T. Tian, D. Hurlbut, and J. Cook (NREL) to R. Callejo, D. Hurlbut, and J. Cook, Bureau of Reclamation. October 1, 2015.

National Renewable Energy Laboratory. 2015c. Projected NGS Power Costs – Technical Memorandum from D. Hurlbut (NREL) to R. Callejo, U.S. Bureau of Reclamation. October 21, 2015.

National Renewable Energy Laboratory. 2015d. Annual Technology Baseline and Standard Scenarios -- Annual Technology Baseline (ATB) spreadsheet [ATB_Data_Inputs_V6.xlsm] and ATB Summary Presentation. Internet websites: http://www.nrel.gov/analysis/pdfs/ATB_Summary_V13.pdf, and http://www.nrel.gov/analysis/data_tech_baseline.html . Accessed April 2015.

National Renewable Energy Laboratory. 2012. Navajo Generating Station and Clean-Energy Alternatives: Options for Renewables. June 2012. D. Hurlbut, S. Haase, C. S. Turchi, and K. Burman. Technical Report NREL/TP-6A20-54706.

Navajo Nation, et al. 2013. Lease Amendment No. 1. Amendment No. 1 to Indenture of Lease, Navajo Units 1, 2 and 3 between the Navajo Nation and Arizona Public Service Company, Department of Water and Power of City of Los Angeles, Nevada Power Company dba NV Energy, Salt River Project Agricultural Improvement and Power District, Tucson Electric Power Company.

Navajo Nation, et al. 1969. Navajo Project Indenture of Lease of 1969. Indenture of Lease, Navajo Units 1, 2 and 3 between the Navajo Tribe of Indians and Arizona Public Service Company, Department of Water and Power of City of Los Angeles, Nevada Power Company, Salt River Project Agricultural Improvement and Power District, and Tucson Gas and Electric Company. Internet website: http://ngskmc-eis.net/wp-content/uploads/2014/07/Navajo-Project-Indenture-of-Lease-1969.pdf. Accessed May 24, 2016.

Office of Surface Mining Reclamation and Enforcement (OSMRE). 2011. Environmental Assessment: Kayenta Mine Permit (AZ-0001D) Renewal (Navajo County, Arizona). U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement (Western Region). August 2011. 185 pp + appendices.

Office of Surface Mining Reclamation and Enforcement (OSMRE). 2008. Black Mesa Project Environmental Impact Statement. DOI FES 08-49, OSM-EIS-33. November 2008.

Peabody Western Coal Company (PWCC). 2012, et seq. Kayenta Complex Permanent Program Permit AZ-0001E Life-of-Mine Plan Revision. Submitted to OSMRE May 1, 2012. Last updated March 27, 2015.

U.S. Department of Energy. 2012. Sunshot Vision Study. February 2012. http://www.energy.gov/sites/prod/files/2014/01/f7/47927.pdf.

Chapter 3.0

Affected Environment and Environmental Consequences

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Acronyms and Abbreviations

1969 Lease	Navajo Project Indenture of Lease
BART	Best Available Retrofit Technology
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BM&LP Railroad	Black Mesa & Lake Powell Railroad
BO	Biological Opinion
CAP	Central Arizona Project
CCR	Coal Combustion Residual
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO_2	carbon dioxide
COPC	Chemical of Potential Concern
Co-tenants	Salt River Project, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company
Development Fund	Lower Colorado River Basin Development Fund
EIS	Environmental Impact Statement
EPRI	Electric Power Research Institute
ERA	Ecological Risk Assessment
ESA	Endangered Species Act of 1973
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
km	kilometer
KMC	Kayenta Mine Complex
kV	kilovolt
kW	kilowatt
LTEMP	Long-term Experimental and Management Plan
MW	megawatt
N-Aquifer	Navajo Aquifer
NEPA	National Environmental Policy Act of 1969, as amended
NGS	Navajo Generating Station
NGS Participants	U.S. (Reclamation), Salt River Project, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company
NHPA	National Historic Preservation Act
NNEPA	Navajo Nation Environmental Protection Agency
NO_2	nitrogen dioxide
NO_X	nitrogen oxide
OSMRE	Office of Surface Mining Reclamation and Enforcement
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter of 10 microns or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 microns or less

PFR	Partial Federal Replacement
PWCC	Peabody Western Coal Company
Reclamation	U.S. Bureau of Reclamation
ROW	Right-of-way
SO_2	sulfur dioxide
SRP	Salt River Project Agricultural Improvement and Power District
STS	Southern Transmission System
U.S.	United States
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WTS	Western Transmission System

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3.0 Affected Environment and Environmental Consequences

The purpose of the Affected Environment and Environmental Consequences chapter is to document current environmental, social, and economic conditions (affected environment) and to disclose the potential direct, indirect, and cumulative environmental consequences from implementing the Proposed Action, the action alternatives, and the No Action Alternative (environmental consequences).

The subsections of this introductory Section 3.0 provide: 1) an overview of the scope of the analysis conducted in this chapter; 2) a description of the organization and methodology used to describe the affected environment and environmental consequences for each of the resources evaluated; and 3) an overview of the process by which specific study areas were defined for conducting risk assessments, as well as how the multidisciplinary ecological and human health risk assessments were conducted and used to assist in the evaluation of certain resources.

3.0.1 Overview of the Scope of Analysis

The Proposed Action includes a number of components (the proposed Kayenta Mine Complex [KMC], Navajo Generating Station [NGS], and transmission systems). These components are located in Arizona, southern Utah and eastern Nevada. As a result, a wide range of resources and habitats potentially can be affected. The National Environmental Policy Act defines the affected environment as the environment of the area(s) to be affected or created by the alternatives under consideration (40 Code of Federal Regulations [CFR] Part 1502.15). The environments of the study areas affected or created by the alternatives under consideration are many and varied, and are affected in different ways by the different components.

The effects of a proposed action include direct effects, indirect effects, and cumulative effects. Direct effects are those which are caused by the action and occur at the same time and place. Indirect effects are those which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable effects. Cumulative effects are the impacts on the environment which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions (40 CFR Parts 1508.7 and 1508.8).

The direct and indirect effects of the Proposed Action are the future changes that are the result of the action; however, to appropriately analyze the effects of the Proposed Action, the existing conditions provide an important context and starting point for changes to the environment that would be the result of the Proposed Action. The discussion of cumulative effects considers the effects of past and present actions, including historical and existing NGS, Kayenta Mine, and transmission system operations, as well as reasonably foreseeable future actions, where the project may have some incremental impact, even if it is negligible.

The majority of the analysis in the Environmental Impact Statement (EIS) is written from a Western scientific perspective. The subsection on Sociocultural Conditions and Trends in Section 3.18.3.1 (Socioeconomics) provides a description of the contemporary sociocultural setting in which the Proposed Action and action alternatives would occur. Many aspects of the contemporary sociocultural setting are rooted in traditional Native American culture and values. Native American traditional values are complex, and in many cases, not easily translated into English or effectively described by Western concepts or thinking. Section 3.18.3.3 provides a discussion of the natural and sociocultural resources, the environment, and traditional occupancy and use of land by the affected Native American community members from a traditional perspective. Insights into traditional perspectives draw upon tribal documents, summaries prepared by ethnographers with the participation or oversight of tribal historic preservation staff, and from ethnographic research documents and other published materials. Scoping comments and comments provided during listening sessions at the Kayenta Mine also helped inform the review of concerns based in Native American traditional values.

While the total project impact for each resource will be the sum of the direct, indirect, and cumulative impacts from all project components, the scope of the analysis will focus on effects by resource and by project component, because each of these will have different effects. The total project effects are presented in the Impact Summary Table in Chapter 2.0.

3.0.2 Organization and Methodology for the Affected Environment and Environmental Consequences Chapter

The Affected Environment and Environmental Consequences chapter is organized by resource topic (e.g., air quality and climate). The discussion for each topic in subsequent sections of Chapter 3.0 (e.g., Sections 3.1, 3.2, 3.3, etc.) is organized as follows.

3.0.2.1 Regulatory Framework

This section identifies for each resource the federal, tribal, and state regulatory programs that set numeric and qualitative standards for minimizing and controlling impacts. Compliance with these standards was considered in defining study areas and context for the impact assessments.

3.0.2.2 Study Areas

Potential effects vary by resource. The scope of analysis for each resource is defined by the potential areas affected (i.e., study area), the project components that may affect that study area, and the types of effects that could occur. The Proposed Action and alternatives study areas for direct impacts to surface resources (e.g., soils, vegetation) are primarily defined by existing and proposed project surface disturbance. Because both NGS and the proposed KMC are existing industrial facilities, the historical surface disturbance through 2019 is differentiated from future surface disturbance planned to occur from 2020 to 2044. These study areas are defined for each resource in the form of narrative and/or maps.

The Proposed Action and alternatives study areas for indirect impacts (e.g., deposition of trace metals from NGS stack and secondary emissions (e.g., fugitive dust from coal handling or ash disposal), mine-generated fugitive dust and consequent bioconcentration through terrestrial and aquatic food chains) are defined by the modeled NGS and proposed KMC air quality impacts over a near-field scale (out to 50 km) and a regional scale (out to 300 km) for NGS only. The basis for the risk assessment study areas is further discussed in Section 3.0.3.

The Proposed Action and alternatives study area for direct and indirect impacts of mine and community groundwater pumping on Black Mesa and surrounding area is the Navajo Aquifer (N-Aquifer), which is illustrated in Section 3.7, Water Resources, **Figure 3.7-2**.

Cumulative impact study areas are resource-specific and are defined to address the area of influence of past and present actions, the Proposed Action and other alternatives, and foreseeable future actions that overlap the range or occurrence of different resources.

Table 3.0-1 provides a summary of the surface disturbance associated with past and present actions, the Proposed Action, and reasonably foreseeable actions described later in this section. **Table 3.0-2** provides an estimate of the project surface area that will require topsoiling and reseeding at the end of 2019 in the event that the No Action Alternative is selected, and in 2044 at the end of the operating period evaluated in this EIS. For purposes of analysis, the following assumptions were made:

- 100 acres of surface facilities and buildings would remain at NGS as specified by the Lease Amendment No. 1 (or a leasing agreement with the Navajo Nation having similar terms as the 1969 Lease and Lease Amendment No. 1). The maximum footprint was assumed (3-Unit Operation, CCR landfill expansion). All demolition and reclamation of NGS would be completed by 2046 per Lease Amendment No. 1 (or a leasing agreement with the Navajo Nation having similar terms as the 1969 Lease and Lease Amendment No. 1), although one unit could be removed earlier. The same footprint would require treatment, regardless of the demolition schedule;
- All surface facilities would be removed from Kayenta Mine, although no specific agreements are in place; and
- The Kayenta Mine ratio of the amount of mining surface area disturbed and "graded but not seeded reclamation" in 2044 would be similar to the estimates for 2019, due to the practice of regrading concurrently with surface mining operations. This estimate is based on a 8.1 million tons per year (tpy) mining rate, similar to historical operations. A 5.5 million tpy mining rate under a 2-Unit NGS Operation is assumed to result in the same surface area to be reclaimed as the 8.1 million tpy operation.

3.0.2.3 Affected Environment

"The environmental impact statement shall succinctly describe the environment of the area(s) to be affected or created by the alternatives under consideration. The descriptions shall be no longer than is necessary to understand the effects of the alternatives" (40 CFR Part 1502.15). To meet this requirement, affected environment information is presented in summary form in the main body of the EIS, with reference to appendices and reports that support the discussion.

The content of the affected environment sections provides background for the issues presented in the Environmental Consequences and Mitigation sections for each resource. As described previously, the affected environment for each resource describes the conditions of the environment as of the end of 2019, when the current NGS lease expires. This section describes the existing environment, including the impacts of past and present human activities to capture and disclose the impacts of historical operations of NGS and the proposed KMC on resource values. The description forms the basis for the effects analysis in the Environmental Consequences and Mitigation section. In some instances, conditions at the time of the EIS preparation have been extrapolated to the end of 2019 to provide a common basis for all resource topics. Where this has been done, it is noted and explained.

Table 3.0-1 Surface Disturbance (Acres) Summary for Past and Present Actions, Proposed Action, and Reasonably Foreseeable Future Actions

Project Component	Past/Present Actions	Proposed Action 3-Unit NGS	Proposed Action 2-Unit NGS	Other Reasonably Foreseeable Future Actions	Total (3-Unit NGS)	Total (2-Unit NGS)
NGS	**3,485**	—	—	—	**3,724**	**3,684**
Power Plant and Coal Combustion Residual (CCR) Landfill	1,785	239	199	—	—	—
CCR Landfill Road	30	—		—	—	—
Water Supply Facilities	50	—		—	—	—
Black Mesa & Lake Powell (BM&LP) Railroad	1,620	—		—	—	—
Proposed KMC	**26,187**[1]	—		—	**31,475**	**30,986**
Coal Resource Area		5,230[5]	4,741[5]	—	—	—
NN Road 41		58	58	—	—	—
Transmission Lines and Communication Sites	**23,114**	—	—	**4,201**[6]	**27,315**	**27,315**
Western and Southern STS Transmission Systems (WTS and STS)	17,212[2]	—	—	—	—	—
Roads	5,752[3]	—	—	—	—	—
Substations, Switchyards, and Communication Sites	150 [4]	—	—	—	—	—
Total	**52,786**	**5,527**	**4,998**	**4,201**	**62,514**	**61,985**

1 Represents total historic surface disturbance within the proposed KMC from mining, surface support facilities, roads, ponds, and other minor surface disturbance through 2015 (Peabody Western Coal Company [PWCC] Annual Reclamation Report, May 2016) plus estimated new mining surface disturbance through 2019 (Lehn 2016).

2 Transmission line Right-of-Way (ROW) – 200-330 feet wide. Source: **Appendix 1B**, Navajo Project Operation and Maintenance Plan, Appendix A, Land and Ownership by Facility

3 Access Road ROW – 50 feet wide. Access roads may be located within the 200-330-foot transmission line ROW, but were calculated separately based on actual road lengths.

4 Substations, Switchyards, and Communications Sites. Source: **Appendix 1B**, Navajo Project

5 Coal resource areas include mine pits, pit access ways, and soil and overburden piles, and transmission lines for dragline electrical power.

6 New Las Vegas area transmission line ROWs – 200 feet wide; new Lake Powell water pipeline and pump station transmission line ROWs – 200 feet wide.

Table 3.0-2 Land Acreage to be Reclaimed

	NGS[1]	Kayenta Mine[2]	Total
2019 – No Action	3,624	5,648	9,272
2044 – Proposed Action or Alternatives	3,624	6,499	10,123

[1] Maximum NGS/railroad footprint (3,724 acres) – 100 acres for remaining structures.

[2] Kayenta Mine: Initial Program Unreclaimed; Initial Program Backfilled and Graded but not Topsoiled or Seeded; Permanent Program Unreclaimed; Permanent Program Backfilled and Graded but not Topsoiled or Seeded. These estimates also include surface facilities that would require decommissioning.

3.0.2.4 Environmental Consequences

3.0.2.4.1 Issues

Environmental issues evaluated under Environmental Consequences in each resource section were developed from public scoping, agency input, and requirements to track impacts through different media as part of ecological and human health risk assessments. The topic headers within the sections outline the issues that are addressed.

3.0.2.4.2 Assumptions and Impact Methodology

For each resource, this section describes the assumptions and procedures used to estimate impacts and the sources for the methodology used. Coordination among agencies to review proposed methods, and independent peer reviews by outside parties are described. The resulting protocols and supporting technical reports are included as appendices to the EIS.

3.0.2.4.3 Proposed Action

Due to the uncertainty regarding the amount of power that NGS would be required to generate subsequent to the divestiture of existing Co-tenants Los Angeles Department of Water and Power and NV Energy by the end of 2019, the EIS evaluates a Proposed Action that would operate over a range between a 3-Unit Operation and a 2-Unit Operation, as described in the following bullets for the NGS and proposed KMC. The specific operational activities are summarized in Section 1.7.1 for NGS, and Section 1.7.2 for the Kayenta Mine.

- The Proposed Action at the NGS evaluates impacts over a range from a 3-Unit Operation (2,250 megawatts [MW]) operation at the upper bound to a 2-Unit Operation (1,500 MW) at the lower bound, along with the operational impacts of associated NGS facilities (i.e., water supply pumping plant and pipeline, ash disposal site, BM&LP Railroad, and other ancillary plant facilities). Other possible operational scenarios and resulting impacts would lie between these upper and lower bounds.
- The Proposed Action at the proposed KMC evaluates the impacts of mining 8.1 million tpy to support an NGS 3-Unit Operation and the impacts of mining 5.5 million tpy to support an NGS 2-Unit Operation. Other possible operations and resulting impacts would lie between these upper and lower bounds. The geographic area of the Proposed Action encompasses coal resource areas planned for mining between 2020 and 2044, and the Navajo Route 41 realignment (**Figure 2-1**).

The Proposed Action for each of the three major project components (NGS and associated facilities, proposed KMC, and the transmission systems and communication sites) are evaluated separately because the operations of each component are different, resulting in different environmental impacts. In addition, while the actions authorizing these components are connected for EIS analysis, they are separated geographically, and most efficiently described separately. However, where the potential impacts of operations of the components would overlap (e.g., air emissions and deposition impacts from

NGS and the proposed KMC on human health and ecological communities), the technical analyses capture and the EIS discloses the combined effects and impacts on the environment.

The transmission systems (Western Transmission System [WTS] and Southern Transmission System [STS]) and communications sites are an established part of the western U.S. transmission grid and support reliability and delivery of power throughout the region, well beyond the power generated by the NGS. The focus of this EIS analysis for the Proposed Action and action alternatives is on continued operation and maintenance of the existing transmission lines, which require infrequent vehicle and equipment travel on existing access roads to the transmission system infrastructure and powerline ROWs corridor. In the event it is determined that some or all of the transmission systems and communication site ROWs are not renewed, a lengthy study and permitting process would need to occur before any decommissioning is initiated due to the essential and integral nature of these facilities with the western electric grid. See Section 2.3.3.3 for a description for analysis of the No Action Alternative.

For each resource, the Proposed Action is discussed by project component and then by impact issue or topical area. Impacts (which may be either adverse or beneficial) are expressed numerically or in narrative form, with a discussion of impact importance or compliance with certain regulatory thresholds. In some instances, the intensity and duration of impacts may be reduced through implementation of mitigation measures. Mitigation measures are described in terms of practicality (including cost if available) and effectiveness. Impacts remaining after mitigation are then estimated and compared across alternatives. Calculations used to estimate impacts are included in appendices that are referenced in the individual resource sections, where applicable. An impact magnitude conclusion and rationale for the conclusion is provided for each major impact topic in accordance with the following definitions:

- **None**. No impacts to the resource.
- **Negligible:** The impact to the resource would be at or below the levels of detection. It would be slight or not perceptible.
- **Minor:** The impact would be detectable but would not be outside the natural or typical range of variability. The impact could be of higher intensity, but short-term or infrequent or could occur more frequently or for a longer period of time but be of lower intensity. Mitigation, if implemented, would be easily applied and successful with a high degree of certainty.
- **Moderate:** The effects would be readily apparent and would result in measurable impacts to the resource. These impacts would affect the availability or natural recovery of those environmental elements over the long term. The impact could be substantial but of a short duration with no permanent impact to the resource. It is anticipated that mitigation, if implemented, would be successful with a high degree of certainty, based on prior examples with similar effects, and documented mitigation outcomes.
- **Major:** The effects would result in substantial impacts to the resource that would be readily apparent, consequential, and outside the natural or typical range of variability. Mitigation, if implemented, would be uncertain in its success, or ineffective with consequent long-term and permanent changes in the availability or natural recovery of the resource.

A summary is provided after the treatment of the discrete project components to provide an overall understanding of the project impacts to a particular resource, and to provide a basis for understanding how the entire project impact contributes to the cumulative impacts.

Preliminary determinations for effects to threatened and endangered species are contained in the Reclamation Biological Assessment, published concurrently with this Draft EIS. The determinations follow the terminology contained in the Endangered Species Act (ESA), and the implementation guidance (USFWS and National Marine Fisheries Service 1998). **Table 3.0-3** provides a general correlation of the EIS impact magnitude criteria to ESA effect determinations used in the Biological Assessment.

Table 3.0-3 EIS Impact Magnitude Correlation to Biological Assessment Effect Determinations

EIS Impact Magnitude	Biological Assessment Determinations	Biological Assessment Determination Definitions (USFWS and National Marine Fisheries Service 1998)
None	No Effect	The appropriate conclusion when the action agency determines its proposed action will not affect listed species or habitat.
Negligible	May affect – is not likely to adversely affect	*May affect* – the appropriate conclusion when a proposed action may pose any effects on listed species or designated critical habitats. *Is not likely to adversely affect* – the appropriate conclusion when effects on listed species are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects to the species. Insignificant effects relate to the size of the impact and should never reach a scale where a take occurs. Discountable effects are those extremely unlikely to occur. Based on best judgement, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur.
Minor, Moderate, Major[1]	May affect – is likely to adversely affect	*May affect* – the appropriate conclusion when a proposed action may pose any effects on listed species or designated critical habitats. *Is likely to adversely affect* – the appropriate finding in a biological assessment (or conclusion during informal consultation) if any adverse effect to listed species may occur as a direct or indirect result of the proposed action or its interrelated or interdependent actions, and the effect is not: discountable, insignificant or beneficial. In the event that the overall effect of the proposed action is beneficial to the listed species, but is also likely to cause some adverse effects, then the Proposed Action "is likely to adversely affect" the listed species.

[1] No major impacts were identified for listed species in the EIS.

3.0.2.4.4 Cumulative Impacts

Cumulative impacts are defined as "the impact on the environment which results from the incremental impact of the action when added to other past and present actions and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time" (40 CFR Part 1508.7).

The following factors were considered in developing the cumulative impact assessment for each resource:

- **Cumulative Impacts Issues.** Resource issues that were evaluated for direct and indirect impacts also are evaluated to determine impacts that may occur when the incremental effects of the Proposed Action or other action alternatives are added to other past and present actions or reasonably foreseeable actions.
- **Geographic Scope of the Cumulative Impacts Analysis.** The geographic areas for cumulative analysis are determined for each resource issue by defining the geographic boundaries of a study area that is predicted to encompass the impacts of the Proposed Action or action alternative, as well as the relevant past and present actions and reasonably foreseeable future actions. A rationale is provided for each cumulative impacts study area.
- **Time Frame for the Cumulative Impacts Analysis.** The cumulative impact analysis time frames vary by resource and resource issue, and are dictated by the past and present, and

foreseeable actions that have been included in the analysis. For example, the Kayenta Mine groundwater analysis model includes a defined starting point for past actions, incorporates the pumping effects of the Proposed Action, and establishes a future impact endpoint that accounts for the cumulative effects of all actions after project groundwater pumping stops in 2057. Time frames for this EIS are defined as follows:

- Short-term: 2 years or shorter in duration
- Long-term: More than 2 years in duration

As the Proposed Action and Partial Federal Replacement (PFR) alternatives are planned to occur over a 25-year time frame, the majority of impacts would be long-term. When the time frame for an impact is not stated, it is assumed to be a long-term impact.

3.0.2.4.4.1 Past and Present Actions

The past and present actions that contribute to historical conditions (through 2019) are described in Chapter 1.0. The primary time frame for most past and present actions for NGS extends from the construction of the generating station in the mid-1970s through 2019; the time frame for the area encompassed within the mine lease area is the inception of mining on Black Mesa in the late 1960s through 2019.

- **NGS**: all facilities and operations within the plant site boundary (railroad loadout, coal storage, generation units, waste water ponds, landfills) through 2019; water supply pumping station, pipeline, 230-kilovolt (kV) transmission line and access road through 2019; CCR landfill (inactive and active areas through 2019), and access road. BM&LP Railroad, including the loadout silos at the terminus of the Kayenta Mine conveyor; railroad track from the loop at the loadout silos to the storage yard at NGS; track sidings.
- **Proposed KMC**: Former Black Mesa Mine reclaimed area, former Black Mesa Mine surface facilities; Kayenta Mine surface facilities, Kayenta Mine reclaimed and active mining areas through 2019; transportation infrastructure (haul roads, overland conveyor, power lines); water supply wells; water management infrastructure (temporary and permanent ponds); Navajo Route 41 (historical alignment through 2019).
- **Transmission System and Communication Sites**: The WTS and STS transmission line, switchyard, and substation ROWs; primary and secondary roads providing access to the transmission line ROWs. Nineteen communication sites (ROW or lease area), and associated access roads.

3.0.2.4.4.2 Reasonably Foreseeable Future Actions

The reasonably foreseeable future actions are described here because the activities associated with these actions would intersect or interact with the NGS and Kayenta Mine operations from 2020 through decommissioning, resulting in cumulative impacts. Identification of the reasonably foreseeable future actions is necessary to establish resource study areas that encompass the past and present actions, Proposed Action and action alternatives, and the reasonably foreseeable future actions.

Reasonably foreseeable future actions are defined as actions that are not speculative – they have been approved, are included in short- to medium-term planning and budget documents prepared by government agencies or other entities, or are likely to occur given trends (U.S. Environmental Protection Agency [USEPA] 1999). Potential future actions were identified through public and agency scoping, input from cooperating agencies, and available information on known projects or actions under consideration. Actions that meet all of the following criteria were considered reasonably foreseeable and are included in the cumulative impacts analysis for each resource:

- The impacts of the future action would occur within the same geographic area (impact area) and the same time frame as the impacts for the Proposed Action or other alternatives.
- The future action would affect the same environmental resources as the Proposed Action or other alternatives.
- There is a reasonable expectation the future action would occur; the future action is not speculative.
- There is sufficient information available to define the future action and assess cumulative impacts.

Based on the criteria above, the following foreseeable actions were identified as potential contributors to cumulative impacts in conjunction with the Proposed Action and action alternatives. **Figures 3.0-1** and **3.0-2** provide regional overviews of the foreseeable actions addressed in this EIS. A brief description of the action, its location, and its cumulative impact relationship to NGS and proposed KMC project components are provided below.

3.0.2.4.4.2.1 Regional Coal-fired and Other Generation Sources; other Regional Emissions Sources

The far-field photochemical air quality modeling (out to 300 km from NGS) incorporates future emissions changes resulting from expected modifications to coal-fired power plant operations needed to comply with the regional haze rule over the next 10 years as described in the 2025 USEPA projected emissions inventory indicated below. These changes include shutting down units and adding equipment to reduce nitrogen oxide. Major sources are shown in **Figure 3.1-1** and provided in **Table 3.1-3**.

For purposes of this EIS, emissions for the period of the Proposed Action are based on the following assumptions regarding reasonably foreseeable actions:

- The shutdown of two units at the San Juan Generating Station and installation of selective catalytic reduction on the remaining units during the action period of the Proposed Action (also see San Juan River Basin Water Uses and Projects below) (**Figure 3.0-2**).
- The shutdown of three units at the Four Corners Power Plant and installation of selective catalytic reduction on the remaining units during the action period of the Proposed Action(also see San Juan River Basin Water Uses and Projects below) (**Figure 3.0-2**).
- Emissions from other major sources, based on the database representing the 2025 emissions inventory developed by USEPA to develop the Particulate Matter Rule for the National Ambient Air Quality Standards (available at http://www.epa.gov/ttn/chief/emch).

For the NGS-KMC Project EIS air quality cumulative impact analysis, project emissions (including both NGS and the Kayenta Mine) were combined with the emissions from these regional sources to predict far-field concentrations of criteria air pollutants. Criteria pollutants and/or hazardous air pollutants were included in the cumulative analysis of visibility and regional haze; acid deposition effects on ecosystems; contributions to regional greenhouse gases affecting climate change; and trace metal deposition and uptake effects on special status fish and other species in the Colorado River watershed. Global mercury emissions and deposition rates were included as cumulative sources in the Ecological Risk Assessments (ERAs) and Human Health Risk Assessments (HHRAs) (Electric Power Research Institute [EPRI] 2016).

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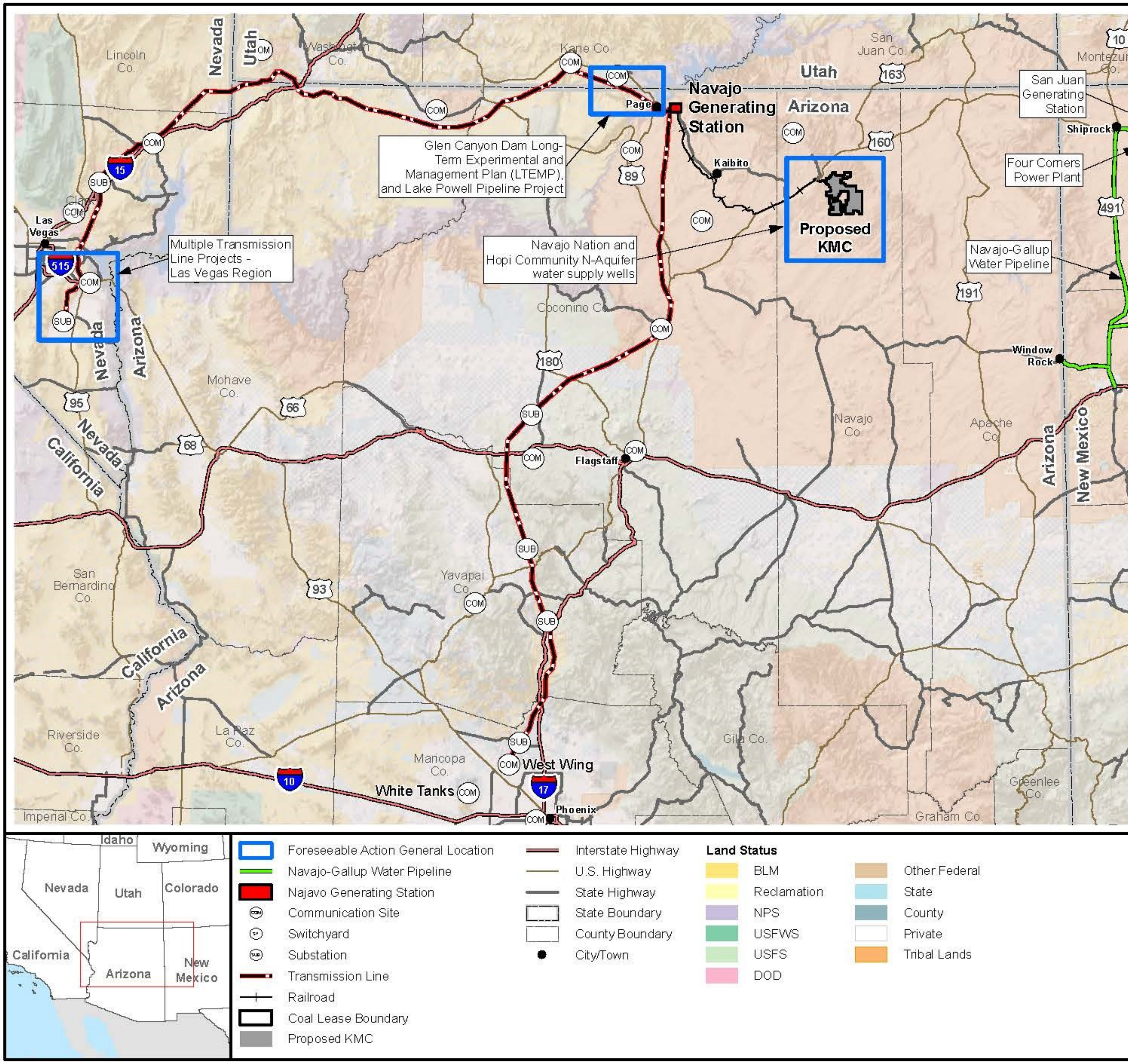

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 3.0-1
Foreseeable Actions
Regional Overview

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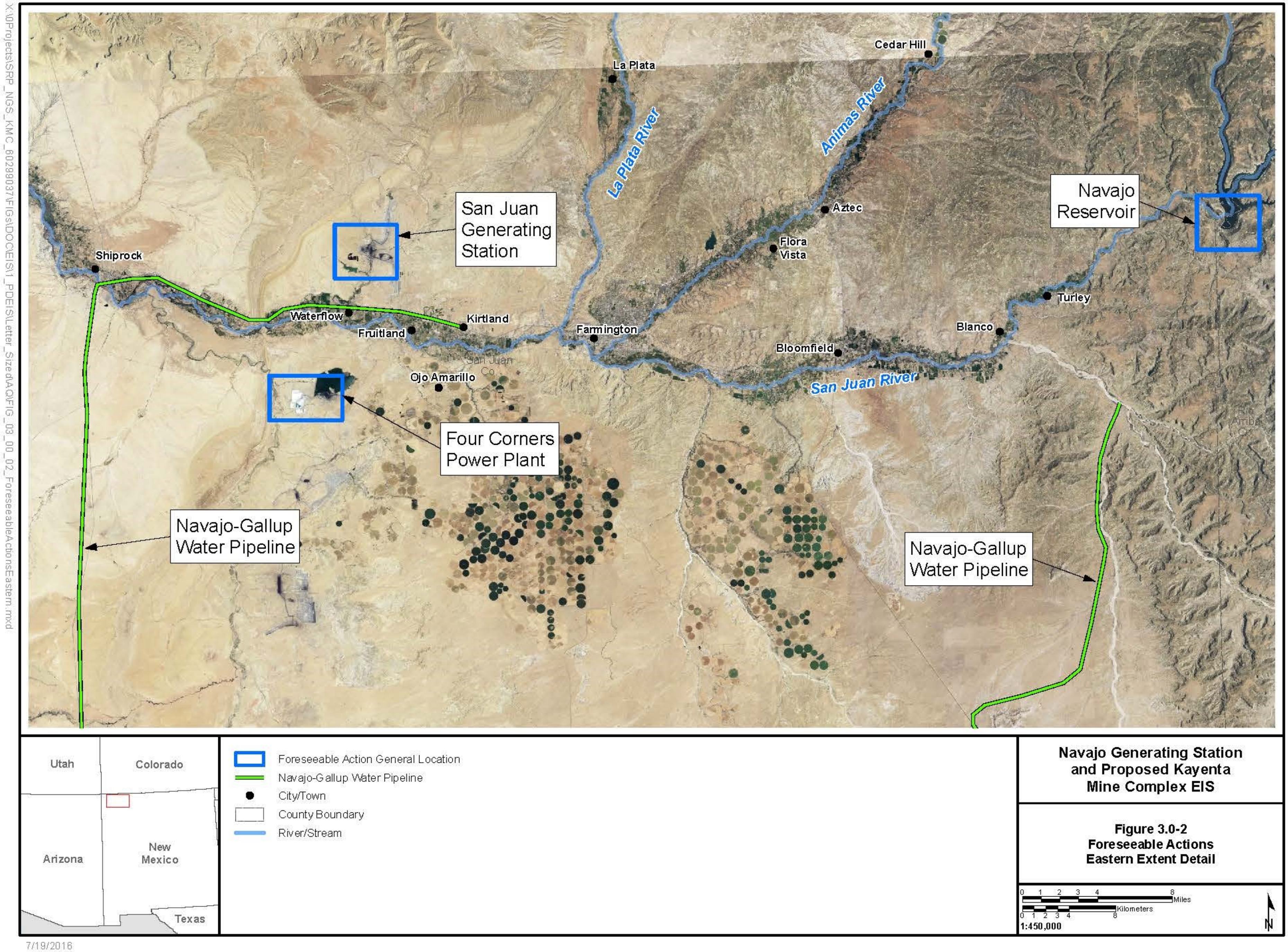


Figure 3.0-2
Foreseeable Actions
Eastern Extent Detail

3.0.2.4.4.2.2 San Juan River Basin Water Uses and Projects

The San Juan River Ecological Risk Assessment (EPRI 2016) suggested potential impact to water quality and aquatic resources in the San Juan River Basin resulting from future NGS emissions. The upper San Juan River watershed encompasses a large area of southwestern Colorado. The river flows from Colorado into northwestern New Mexico and then across southern Utah to its confluence with Lake Powell. The primary San Juan River surface water storage is Navajo Reservoir east of Farmington, New Mexico, which is used as a regulator for a variety of diversions and releases for downstream users and instream resources, such as listed native fish species. A variety of municipal, agricultural, and industrial diversions are located above and below Navajo Reservoir. These include the Navajo Indian Irrigation Project; several irrigation company diversions; municipal diversions for Farmington, Aztec, Bloomfield, and Shiprock; and cooling water diversions for the San Juan and Four Corners power plants.

The following are foreseeable projects that would modify existing diversions or require new diversions from the river (**Figure 3.0-2**). These projects have received prior federal approvals, but project implementation would continue after 2019, coinciding with the Proposed Action analysis period for the NGS-KMC Project EIS.

Navajo-Gallup Water Pipeline. This project was approved in 2009 and is under construction. The purpose of this project is to provide new sources of water to a variety of Navajo Nation communities including Gallup, New Mexico. The project was analyzed in an EIS (U.S. Bureau of Reclamation [Reclamation] 2009), and a Biological Opinion (U.S. Fish and Wildlife Service 2009) was prepared that addressed project effects on the listed fish habitat in the river. The project would divert approximately 38,000 acre-feet from the San Juan River. However, this future depletion is almost entirely offset by Navajo Nation unused water assigned to the Navajo Indian Irrigation Project. San Juan River flows would be protected and maintained under a Depletion Guarantee, which sets an overall depletion threshold for the upper San Juan River Basin (U.S. Fish and Wildlife Service 2009). The Navajo Reservoir would continue to be operated to maintain the recommended river flow pattern specified in the San Juan River Basin Recovery Implementation Program.

Hogback-Cudei and Fruitland Canal Rehabilitation Projects. These irrigation projects were constructed for the benefit of the Navajo Nation between Farmington and Shiprock, New Mexico, in the early 1900s. The canals for these projects are proposed to be rehabilitated to reduce seepage losses, and improve water delivery efficiency to the irrigated lands. The environmental evaluation for these projects is being conducted by the Bureau of Indian Affairs.

San Juan Generating Station. In a Best Available Retrofit Technology agreement with USEPA, this Public Service of New Mexico 1,800-MW coal-fired power plant would shut down two units and install selective catalytic reduction units on the remaining two stacks. The shutdown for two units is scheduled for the end of 2017. Current diversions from the San Juan River are approximately 16,200 acre-feet per year (U.S. Fish and Wildlife Service 2009). The shutdown of two units would reduce water consumption by approximately 50 percent or 8,100 acre-feet (Public Service of New Mexico 2015).

Four Corners Power Plant. The Four Corners Power Plant diverts water from the San Juan River into Morgan Lake, a storage reservoir. As a result of a Best Available Retrofit Technology agreement with USEPA, the Four Corners Power Plant shut down three of five units in 2013, with an approximately 60 percent reduction in cooling water needs. On July 14, 2015, the Office of Surface Mining Reclamation and Enforcement issued a Record of Decision (Office of Surface Mining Reclamation and Enforcement 2015) that approved surface coal mining in existing and new Navajo Mine permit areas, a lease for the Four Corners Power Plant, and various ROWs for transmission lines and roads. The project Biological Opinion (U.S. Fish and Wildlife Service 2015) was attached to the Record of Decision. The Biological Opinion contains conservation measures designed to offset project impacts on threatened and endangered species, primarily the Colorado pikeminnow and the razorback sucker. The major areas addressed in the conservation measures are reduction of larval fish impingement and entrainment at the power plant diversion structure; non-native fish control measures; construction of fish passage structures; monitoring for effects of selenium and mercury in listed fish; fish habitat improvement within the San Juan River channel; support for the San Juan River Basin Recovery Implementation Program; water temperature effects study on Colorado pikeminnow; and implementation of surveys for southwestern willow flycatcher, western yellow-billed cuckoo, and endangered plant species.

For aquatic biology and special status species, there is a cumulative impacts overlap between NGS trace metal deposition impacts to the Colorado pikeminnow and the razorback sucker in the San Juan River watershed, and trace metal deposition from the power plant projects listed above in northwestern New Mexico. All projects discussed above divert from the San Juan River, which in turn affect the quantity and quality of riverine habitat downstream of the New Mexico/Utah border. The Endangered Species Act consultations and Biological Opinions for these projects provide background for ongoing Endangered Species Act consultations for the NGS-KMC Project.

Gold King Mine water release into the Animas River. On August 5, 2015, approximately 3 million gallons of acid mine drainage water were accidentally discharged from the Gold King Mine into the upper Animas River drainage in Colorado. The Animas River is a major tributary of the San Juan River. Water quality and sediment monitoring programs were immediately initiated by state and federal agencies at intervals along the Animas and San Juan River. The Utah Department of Water Quality conducted water quality sampling at five San Juan River locations from Montezuma Creek to Mexican Hat from August 2015 through October 2015 (UDWQ 2016a). Sample results were compared with human health and aquatic life screening levels over multiple sampling periods. Post-release plume metal concentrations in river sediments were both higher and lower than pre-release concentrations at some sampling sites; however, all 2015 sample concentrations were within the historical range of metals concentrations measured in the San Juan system. Additional UDWQ water sampling was conducted in February, March, April, and June 2016 (UDWQ 2016b). The results of this sampling were screened against recreational, drinking water, agricultural, and aquatic life criteria. With the exception of aluminum criteria for aquatic life and total dissolved solids for agriculture, no exceedances of criteria were identified. Monitoring of water quality and sediments will continue to determine the potential for long term trace metal effects on ecological and human health. In March 2016, the USEPA issued a conceptual monitoring plan (USEPA 2016) that addressed Animas and San Juan River water, sediment, macroinvertebrate, and fish sampling scheduled for 2016. The plan included San Juan River sites previously sampled by UDWQ in 2015. Monitoring of the sites included in the USEPA plan may continue after 2016.

3.0.2.4.4.2.3 Glen Canyon Dam Long-term Experimental and Management Plan

The U.S. Department of Interior, through the Reclamation and the National Park Service proposes to develop and implement a Long-term Experimental and Management Plan (LTEMP) for operations of Glen Canyon Dam (**Figure 3.0-1**). The LTEMP would provide a framework for adaptively managing Glen Canyon Dam operations over the next 20 years with the goal of creating certainty and predictability for power and water users while protecting environmental and cultural resources in Grand Canyon National Park and the Colorado River Ecosystem.

The LTEMP Draft EIS (Reclamation and National Park Service 2015) evaluates the effects of different reservoir release alternatives on resources including sediment resources, aquatic and terrestrial ecological resources, historic and cultural resources, resources of importance to Native American Tribes, recreational resources, and designated wilderness in the vicinity of Glen Canyon and the Grand Canyon; as well as socioeconomic resources, hydropower resources, and air quality.

For the aquatic biology and special status species cumulative impact analysis, estimated future instream habitat conditions (i.e., water volume, water chemistry and temperature) resulting from implementation of the LTEMP alternatives were considered in the context of trace metal deposition from the NGS stacks and consequential ecological risks (see Section 3.02, Ecological and Human Risks Assessment). The LTEMP incorporates a number of measures to increase the likelihood of humpback chub (*Gila cypha*) endangered fish recovery and reduction in non-native fish invasion.

The NGS-KMC Project has considered the LTEMP measures in the development of conservation measures included in this EIS and in the resulting Endangered Species Act Section 7 consultation with U.S. Fish and Wildlife Service. The NGS-KMC Project conservation measure program is designed to be consistent with the LTEMP goals and to contribute to overall listed fish recovery goals in the Colorado River system.

3.0.2.4.4.2.4 Lake Powell Pipeline Project

The Utah Board of Water Resources has proposed the construction and operation of a 158-mile water pipeline that would extend from an intake structure in Lake Powell to Sand Hollow Reservoir near Saint George, Utah. In addition to the pipeline, the project would construct transmission lines to provide power to pump stations and to receive power from hydropower generation. Total planned water withdrawal from Lake Powell would be approximately 90,000 acre-feet annually. The project likely would be constructed by 2025, and then would operate indefinitely. The water pipeline (maximum diameter 69 inches) would be constructed in a 120-foot-wide construction ROW and operated in a 100-foot-wide permanent ROW. The 230-kV transmission line would be constructed in a 150-foot-wide ROW.

For the NGS and proposed KMC natural and cultural resources and land surface cumulative analysis, two segments of the Lake Powell Pipeline Project would be located in the existing utility corridor (approximately 500 feet wide) occupied by the WTS in Coconino County, Arizona (**Figure 3.0-3**). From the vicinity of Glen Canyon Dam to Buckskin Mountain, a 230-kV transmission line would be constructed parallel to an existing 138-kV Garkane transmission line as well as the WTS transmission line over a distance of approximately 29 miles. The water pipeline would be located parallel to the WTS over a distance of approximately 33 miles, assuming construction across the Kaibab Band of Paiute Reservation.

For the NGS and proposed KMC water resource cumulative analysis, the magnitude of the proposed Lake Powell pipeline diversions on fisheries habitat in Lake Powell is considered relative to the NGS water withdrawals, lake levels, and associated fisheries habitat.

Primary land surface resource cumulative impact issues that apply to existing and new facilities within the existing utility corridor shared by the WTS and the Lake Powell pipeline and transmission line include soil resources (disturbance and stabilization); vegetation and special status species (removal and revegetation); wildlife and special status species (habitat losses, direct losses of non-mobile individuals, short term displacement from construction activities); land use (expansion of the utility corridor width, temporary reduction in grazing use); transportation (use of existing access roads by multiple utility operations, creation of new roads requiring maintenance); and cultural resources (disturbance of cultural resources, effects on traditional cultural properties).

3.0.2.4.4.2.5 Navajo Nation and Hopi Community N-Aquifer Water Supply Wells

Groundwater modeling for drawdown effects on the regional N-Aquifer, the primary groundwater source for Black Mesa, included assumptions about location and volume of water that would be withdrawn from community wells from 2020 to 2057. The region surrounding the proposed KMC where these communities are located is provided on **Figure 3.0-1**. A detailed discussion of the water demand assumptions is included in Section 3.7, Water Resources.

- <u>Future projections for existing communities</u>. Increases in future water demands were estimated from community population growth projections as well as changes in future per capita demand. The existing communities for which future water demand projections were made include Tuba City, Kayenta, Pinon, Moenkopi District, Shonto, and Polacca.

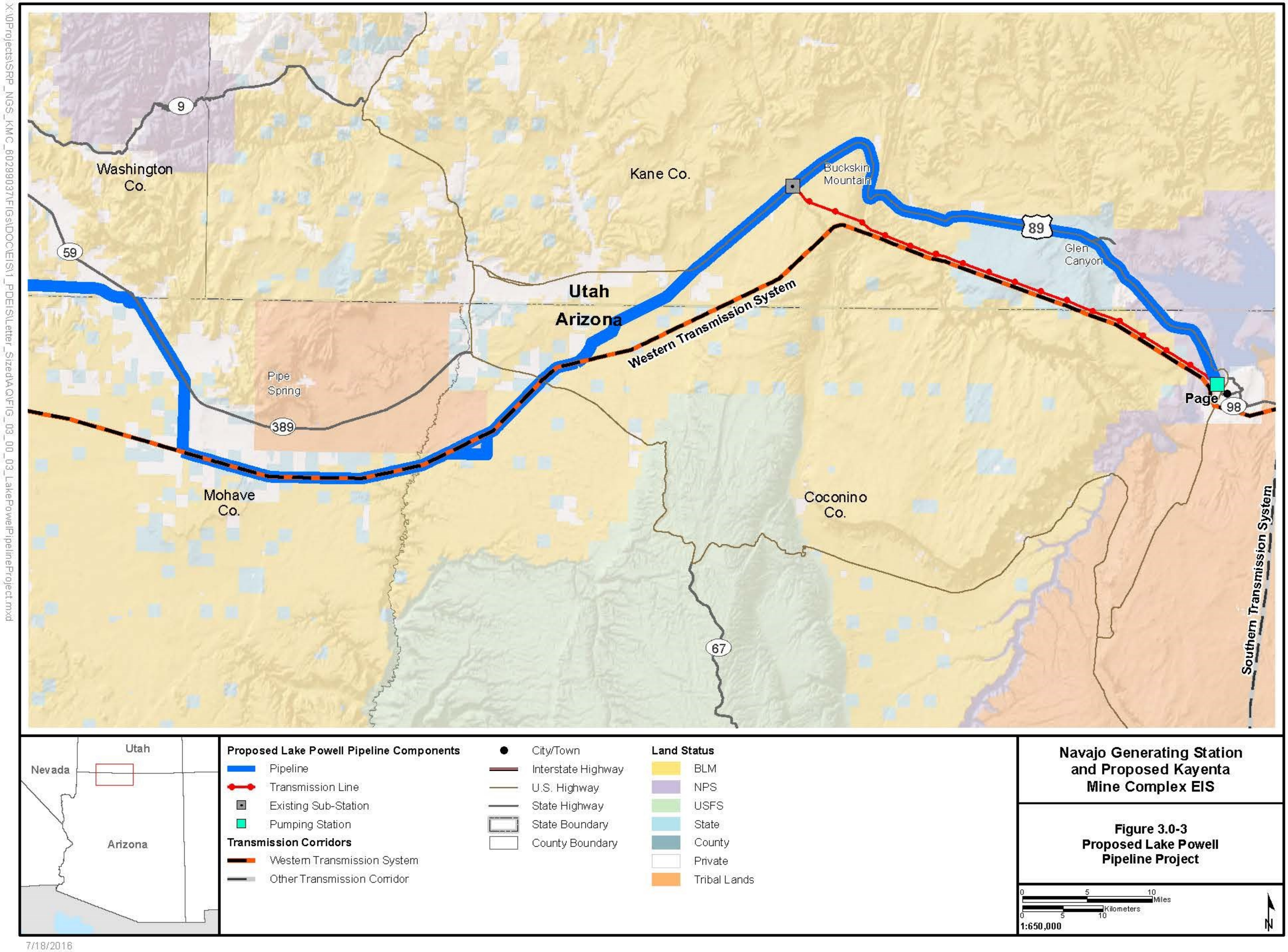


Figure 3.0-3
Proposed Lake Powell Pipeline Project

- Future projections for new communities. New Hopi communities have been proposed at several locations that would require new sources of groundwater supply. These communities include Tawa'ovi, Howell Mesa East and West, Spider Mound, and South Oraibi. The Navajo Nation's Many Mules water development project within the Kayenta Mine area would utilize an existing mine water supply well for domestic use. This water use conversion may occur prior to 2020, however the new extended use has been considered in the groundwater modeling.
- Replacement wells for existing wells. The Hopi Arsenic Mitigation Project to replace arsenic contaminated wells on the Hopi Reservation is planned for completion after 2020, and expected future use was estimated for groundwater modeling.

3.0.2.4.4.2.6 Multiple Transmission Line Projects – Las Vegas Region

Multiple high voltage (230 kV and higher) transmission line projects have recently been proposed for construction within an existing West-Wide utility corridor east and south of Las Vegas; collocated with the WTS. **Figure 3.0-4** illustrates the various projects that may be constructed by 2025 within this utility corridor. These projects are described in relation to the WTS.

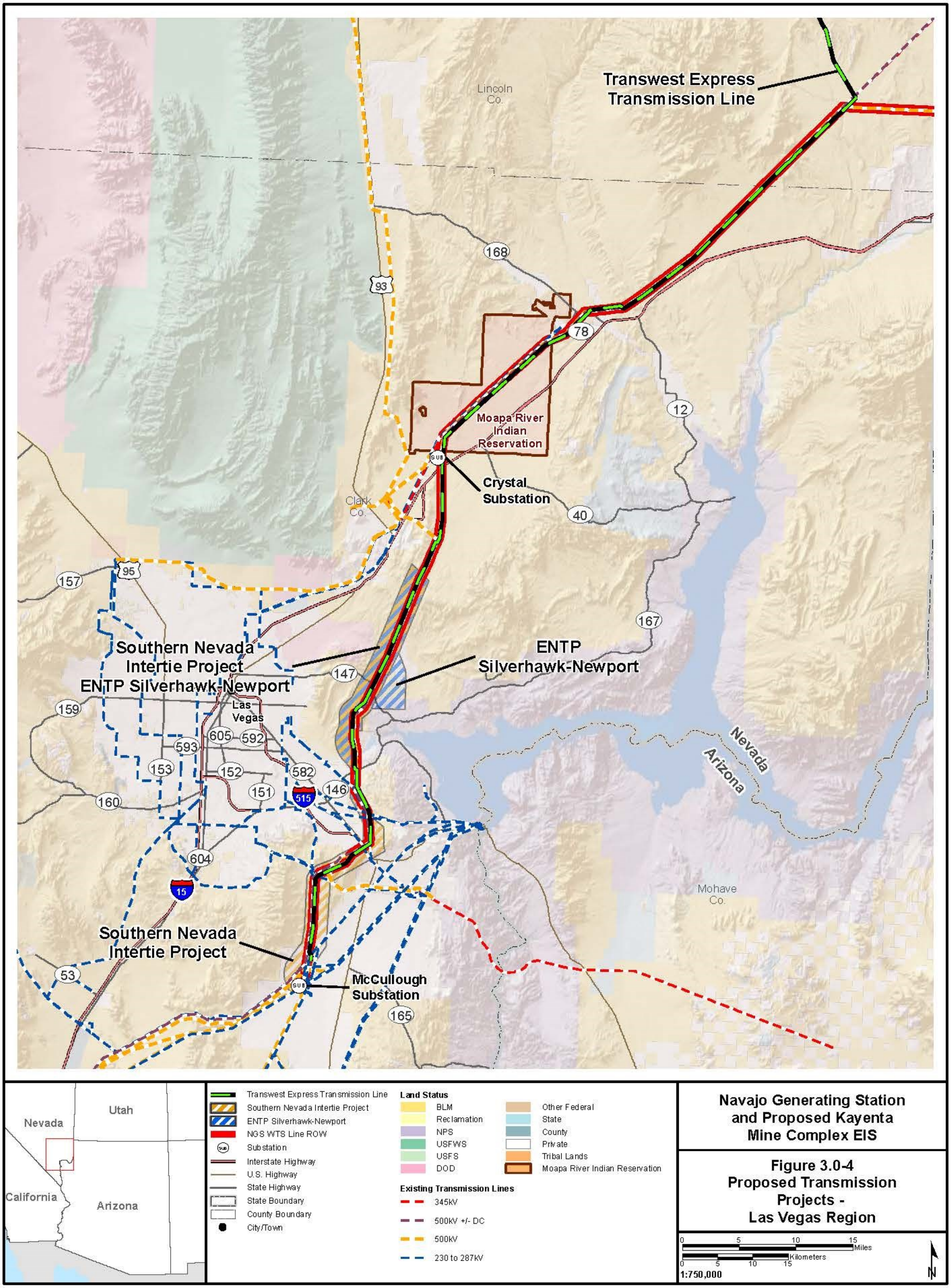
- TransWest Express Transmission Project. The proposed TransWest Express Project is a 725-mile-long, 600-kV direct current transmission line that would extend from central Wyoming to a terminus in the Eldorado Valley south of Las Vegas (Bureau of Land Management [BLM] 2015). Average transmission line ROW width would be approximately 150 feet. The project would utilize existing access roads when located in an existing utility corridor, and new roads would be required where no utility projects currently exist. The BLM Record of Decision for this project is expected in 2016; construction of the project likely would occur over a 5-year period. The TransWest Express Project parallels the WTS over a distance of 102 miles.
- Great Basin Transmission/NV Energy Southern Nevada Intertie Project. The proposed 60-mile 500-kV alternating current transmission line would extend from the Harry Allen Power Plant northeast of Las Vegas to the Mead Substation south of Henderson, Nevada (BLM 2012). The Southern Nevada Intertie Project would parallel the WTS over a distance of 40 miles.
- Silver States Energy Associates Eastern Nevada Transmission Project (ENTP Silverhawk-Newport). The proposed 230-kV alternating current transmission line would extend from the Newport Substation on the southeast side of the Las Vegas metropolitan area north to the Gemmill Substation north of the Silverhawk Power Plant. The Eastern Nevada Project would parallel the WTS over a distance of 23 miles.

The types of expected cumulative land surface resource impacts to terrestrial resources would be similar to those described for the Lake Powell Pipeline project.

3.0.2.4.5 Partial Federal Replacement Alternatives

Three action alternatives to offset part of the federal share of NGS were developed as described in Section 2.3.2. For each PFR alternative (natural gas, renewable, and tribal), the NGS federal power generation share would be reduced (curtailed) by between 100 MW up to 250 MW; proportionally less coal would be mined at the Kayenta Mine. The operational assumptions for these alternatives are discussed in Section 2.3.2 and **Appendix 2A**.

Implementation of the PFR alternatives would proportionally reduce the annual quantity of coal burned at NGS and, consequently, the amount of emissions produced at NGS and annual volume of coal mined at the Kayenta Mine. These changes represent the primary operational differences from the Proposed Action, and can be used to estimate the impact of the action alternatives on resources and human activities at NGS (including the BM&LP Railroad), and the proposed KMC. Where possible, the impacts of the action alternatives were scaled from the impact estimates developed for the Proposed Action for the range represented by the NGS 3-Unit Operation and 2-Unit Operation. However, for air



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 3.0-4
Proposed Transmission Projects - Las Vegas Region

quality near NGS the maximum impacts for criteria air pollutants (except SO_2 and most trace metals) are dominated by emissions from ground-level operational sources at NGS, which would remain the same regardless of whether the 3-Unit Operation or 2-Unit Operation would be implemented. In this case, air impacts were adjusted by the change in power production and by the relative change in impacts from stack emissions, with the emissions from ground-level operational sources remaining constant.

The values estimated by scaling were then used to estimate other indirect impacts. For example, changes in coal production affect the number of mine workers and the amount of new surface disturbance required to achieve a certain amount of production.

The operational factors that used a scaling approach to compare the impacts of the Proposed Action to those of the PFR alternatives are summarized in **Table 3.0-4**, along with resource applicability and rationale for the scaling approach for each factor.

Table 3.0-4 Operational Factors Scaled from the Proposed Action to Estimate Partial Federal Replacement Alternative Impacts

Operational Factors	Resource Applicability	Scaling Approach Assumptions
NGS Power Generation (**Table 3.0-2**)	Socioeconomics, Air Quality, Climate Change, ERA, HHRA, Soils, Water, Vegetation, Wildlife, Aquatic Biology	The changes in NGS output are based on the power generation assumptions for each PFR. These estimates represent a change in NGS output in response to specific assumptions for how the PFR alternative would operate.
NGS Water Use (**Table 3.0-4**)	Water Resources, Aquatic Biology	NGS water use from the Lake Powell source generally is proportional to the power generated. The scaling for water use was derived from NGS power generation.
Proposed KMC Coal Production (**Tables 3.0-5** and **3.0-6**)	Socioeconomics, Geology, Paleontology, Soils, Vegetation, Wildlife, Land Use, Water Resources, Cultural Resources, Environmental Justice, Indian Trust Assets	The changes in volume of coal mined are dependent on the volume of coal burned at NGS to generate electrical power. It is assumed that the same coal resource areas would be mined, but at a lower rate and on a modified schedule compared to the Proposed Action. Surface disturbance estimates are based upon this same scaling approach.
Proposed KMC Groundwater Use	Water Resource, Socioeconomics, Geology, Paleontology, Soils, Vegetation, Wildlife, Land Use, Cultural Resources, Environmental Justice, Indian Trust Assets	Groundwater pumping volumes were assumed to be constant, regardless of the volume of coal mined for the period 2020-2044 because water would be used primarily for dust control along existing roads. Therefore no proposed KMC groundwater use comparisons were made among alternatives.

Table 3.0-4 Operational Factors Scaled from the Proposed Action to Estimate Partial Federal Replacement Alternative Impacts

Operational Factors	Resource Applicability	Scaling Approach Assumptions
Proposed KMC Particulate Emissions – Index for trace metals deposition and air concentrations	ERA, HHRA, Land Use, Soils, Vegetation, Wildlife, Special Status Species	Particulate emissions and deposition cannot be scaled for the proposed KMC due to the number of variables and uncertainties involved; therefore, a qualitative assessment was made.

Tables 3.0-5 through **3.0-8** provide the impact variables that were scaled from the Proposed Action 3-Unit Operation and 2-Unit Operation to provide the proportional differences for each of the PFR alternatives.

Table 3.0-5 Typical NGS Power Generation for the Proposed Action and PFR Alternatives

Power Generation	Proposed Action[1]	Natural Gas PFR		Renewable PFR		Tribal PFR	
		100-MW	250-MW	100-MW	250-MW	100-MW	250-MW
NGS 3-Unit Operation							
MW	1,980	1,880	1,730	1,922	1,834	1,939	1,877
% Change from Proposed Action		-5%	-13%	-3%	-7%	-2%	-5%
NGS 2-Unit Operation							
MW	1,320	1,220	1,070	1,268	1,174	1,279	1,217
% Change from Proposed Action		-8%	-19%	-4%	-11%	-3%	-8%

[1] NGS typical output is operating at 88 percent capacity.

Table 3.0-6 Typical NGS Annual Water Use for the Proposed Action and PFR Alternatives

Typical Water Use	Proposed Action	Natural Gas PFR		Renewable PFR		Tribal PFR	
		100-MW	250-MW	100-MW	250-MW	100-MW	250-MW
NGS 3-Unit Operation							
acre-feet	29,000	27,840	25,230	28,130	27,260	28,420	27,550
% Change from Proposed Action		-4%	-13%	-3%	-6%	-2%	-5%
NGS 2-Unit Operation							
acre-feet	19,340	17,986	16,052	18,566	17,406	18,760	17,986
% Change from Proposed Action		-7%	-17%	-4%	-10%	-3%	-7%

Table 3.0-7 Typical Proposed KMC Annual Coal Production for the Proposed Action and PFR Alternatives

Coal Production	Proposed Action	Natural Gas PFR		Renewable PFR		Tribal PFR	
		100-MW	250-MW	100-MW	250-MW	100-MW	250-MW
NGS 3-Unit Operation							
million tpy	8.1	7.714	7.135	7.875	7.537	7.941	7.701
% Change from Proposed Action		-5%	-12%	-2%	-7%	-2%	-5%
NGS 2-Unit Operation							
million tpy	5.5	5.114	4.535	5.275	4.937	5.341	5.101
% Change from Proposed Action		-7%	-18%	-4%	-11%	-4%	-7%

Table 3.0-8 Typical Proposed KMC Surface Disturbance Estimates for the Proposed Action and PFR Alternatives

Surface Disturbance Estimates	Proposed Action	Natural Gas PFR		Renewable PFR		Tribal PFR	
		100-MW	250-MW	100-MW	250-MW	100-MW	250-MW
NGS 3-Unit Operation							
acres	5,230	4,968	4,602	5,072	4,863	5,124	4,968
% Change from Proposed Action		-5%	-12%	-3%	-7%	-2%	-5%
NGS 2-Unit Operation							
acres	4,741	4,409	3,888	4,551	4,267	4,599	4,409
% Change from Proposed Action		-7%	-18%	-4%	-10%	-3%	-7%

For the transmission systems (WTS and STS) and communications sites, the focus of this EIS analysis for the proposed action and PFR alternatives is on continued operation and maintenance of the existing transmission lines, which require infrequent vehicle and equipment travel on existing access roads to the transmission system infrastructure and powerline ROWs corridor. Additional disturbance of unknown acreage could occur under the Tribal PFR related to construction of a tie-line to connect one or more photovoltaic solar sites to the transmission system.

Cumulative impacts for the PFR alternatives would be considered in a similar fashion as previously described for the Proposed Action.

3.0.2.4.6 No Action

As described in Section 2.3.3, No Action means that none of the federal approvals required for continued operation at NGS or the proposed KMC would be granted and all currently active facilities would cease operations and be decommissioned and the land reclaimed. The No Action Alternative takes into account actions that would continue to occur in the absence of the Proposed Action or other action alternatives. An example is the continued pumping of community wells in the vicinity of the Kayenta Mine to support existing and expanding residential populations.

The NGS transmission system is an established part of the western U.S. transmission grid and supports reliability and delivery of power throughout the region, well beyond the power generated by the NGS. Therefore, under the No Action Alternative it is likely that that one, several, or all of the land owners/managers of the transmission line rights-of-way and communication site leases would renew some portion of the facilities to keep the power grid performing as expected.

In the event it is determined that some or all of the transmission systems and communication site ROWs are not renewed, a lengthy study and permitting process would need to occur before any decommissioning is initiated due to the essential and integral nature of these facilities with the western electric grid. As noted in Section 2.3.3.3, up to 4,826 acres within and alongside the transmission system corridors could be temporarily disturbed if the entirety of the transmission systems and communication sites were decommissioned and removed.

3.0.2.4.7 Comparison of Alternatives

An evaluation of the impacts of the Proposed Action, PFR alternatives, and No Action Alternative is provided in a tabular comparison of impacts at the conclusion of Chapter 2.0.

3.0.3 Ecological and Human Health Risk Assessment Approach and Study Area Delineation

Risk assessment is the estimation of the risk of impairment to human health and/or the environment (plants and animals) posed by chemicals present at naturally occurring levels in the environment or in association with environmental contamination, and is an important part of the environmental study process. The risk assessments conducted are very conservative in nature; i.e., protective of or “conserving” health and wellbeing. Due to the conservative assumptions made in each step of the risk assessment processes, it is likely they overestimate, rather than underestimate, potential risk. Thus, if it is determined that a risk may exist it does not mean that people, plants or animals currently are experiencing any adverse effects or harm but rather suggests that further analysis may be warranted to improve understanding of potential impacts before making an impact determination. Alternately, if the risk assessments conclude that there are no potential for risk or risk is negligible, then no further consideration or additional evaluation would need to occur.

The purpose of the ERA and the HHRA for NGS (and associated facilities) is to trace the movement of chemicals within ecosystems, and then to estimate concentrations of chemicals of potential concern (COPCs) through direct contact and through ecological and human food chains to determine if these chemicals could cause impairment to human health and/or ecological communities, including specific sensitive plant, wildlife, and fish species. The NGS risk assessments consider baseline or existing conditions as well as the impact of future NGS (project) emissions and emissions from other sources (regional and global). Similarly, the Proposed KMC risk assessments evaluate baseline conditions as well as the impact of potential future proposed KMC operations (coal production and reclamation activities to support NGS 3-Unit Operation and 2-Unit Operation), as they relate to ground-level emissions (fugitive dusts), and atmospheric emissions from other (cumulative) sources (regional and global).

Due to the time it takes for project emissions to be deposited and move through ecosystems for future atmospheric emissions, the ERAs and the NGS HHRA assessed the impact of NGS and cumulative emissions for the time period from year 2020 to 2074, 30 years after the planned shutdown of NGS in 2044. The additional 30-year time frame was selected based on the analysis and results of the EPRI study (EPRI 2016) that evaluated trace metal impacts on aquatic organism in the San Juan River watershed. The focus of the EPRI study was to determine the effect of projected changes in source emissions of arsenic, mercury, and selenium on terrestrial and surface water ecosystem concentrations of these chemicals in the San Juan River Basin. The additional 30-year time frame was selected to account for the San Juan River watershed response to future atmospheric deposition. While some atmospheric deposition falls directly onto surface water, most falls on to the larger terrestrial component of the watershed. Given the large storage capacity of soils, the movement of atmospheric inputs through the watershed system and ultimate release to surface water may take years to become evident. Therefore, the watershed response to atmospheric deposition is a function of fate (transformation) and transport processes that dictate the movement of deposited chemicals within the terrestrial, aquatic (surface water) and groundwater components, including movement through the food web.

The HHRA and ERA were used to characterize exposure and potential risk for project-related chemicals of concern under multiple exposure scenarios (baseline, future NGS and proposed KMC operations, and other cumulative sources) and multiple receptors. The risk assessments inform the development of the Affected Environment and Environmental Consequences sections and fulfill, in part, the information needed to fully address these EIS components. Therefore, these assessments inform the analysis of impacts of the Proposed Action and alternatives on soil, vegetation, terrestrial and aquatic resources, and human health. Because of the interdisciplinary inputs required for the risk assessments, an initial outline of the risk assessment approach is provided below, with reference to other locations in the EIS where these topics are discussed. A more detailed overview of the risk assessment process and sources of inputs to the process are presented in **Appendix 3RA**.

The major chemicals of concern addressed in this EIS are focused on substances contained in coal which are then released via power plant stack emissions or fugitive dust from coal combustion residual handling, storage, and disposal (i.e., wind-blown fugitive emissions from the NGS dry ash disposal landfill). Other coal-related sources (unrelated to the combustion of coal) include fugitive dust generated by mining activities and operation and maintenance activities related to coal handling at NGS. The emission impacts of diesel engine emissions (i.e., diesel particulate matter) generated from the proposed KMC and NGS equipment and vehicle use also were analyzed. Trace metal and other chemical concentrations were compiled for ambient air, soils, water, sediment, and fish tissue from recent investigations within the Colorado River drainage, as well as from new field sampling conducted in 2014 in the vicinity of NGS and the proposed KMC. Summaries of background trace metal concentrations for these media are provided in the Affected Environment sections of the Air Quality, Soils, Water Resources, Terrestrial Wildlife, and Aquatic Resources to provide perspective. More detailed summaries are provided in supporting appendices for these resource topics and in each of the risk assessment reports conducted for the project.

The risk assessments were conducted in accordance with the USEPA ERA Guidance (USEPA 2001, 1999, 1998, 1997) and HHRA Guidance (USEPA 2009, 2005, 1989). These guidance documents define the risk assessment framework and process for evaluating the potential for adverse effects. Although some methods and input parameters differ between HHRA and ERA guidance, the overall process components are the same. Key components or steps of the USEPA risk assessment process include:

- **Problem Formulation/Hazard Identification.** Problem formulation and hazard identification comprise the initial planning steps used to guide the risk assessment process. This includes characterizing the site setting, identifying potential chemical hazards and COPC for inclusion in the risk assessment process, and identifying how people and/or plants and animals can be exposed to these chemical hazards. This information is integrated into a conceptual depiction of potential exposed populations (receptors) and the various ways in which they may be exposed to site-related chemicals.
- **Analysis (Exposure/Effects Assessments).** The exposure assessment identifies potential exposure pathways, exposure assumptions and an evaluation of the constituent concentrations to which ecological and human receptors are exposed. The effects assessment describes the toxicity values used to estimate exposure for all exposure pathways and the potential adverse effects associated with the chemicals of potential ecological and human health concern to each receptor defined in the problem formulation/hazard identification.

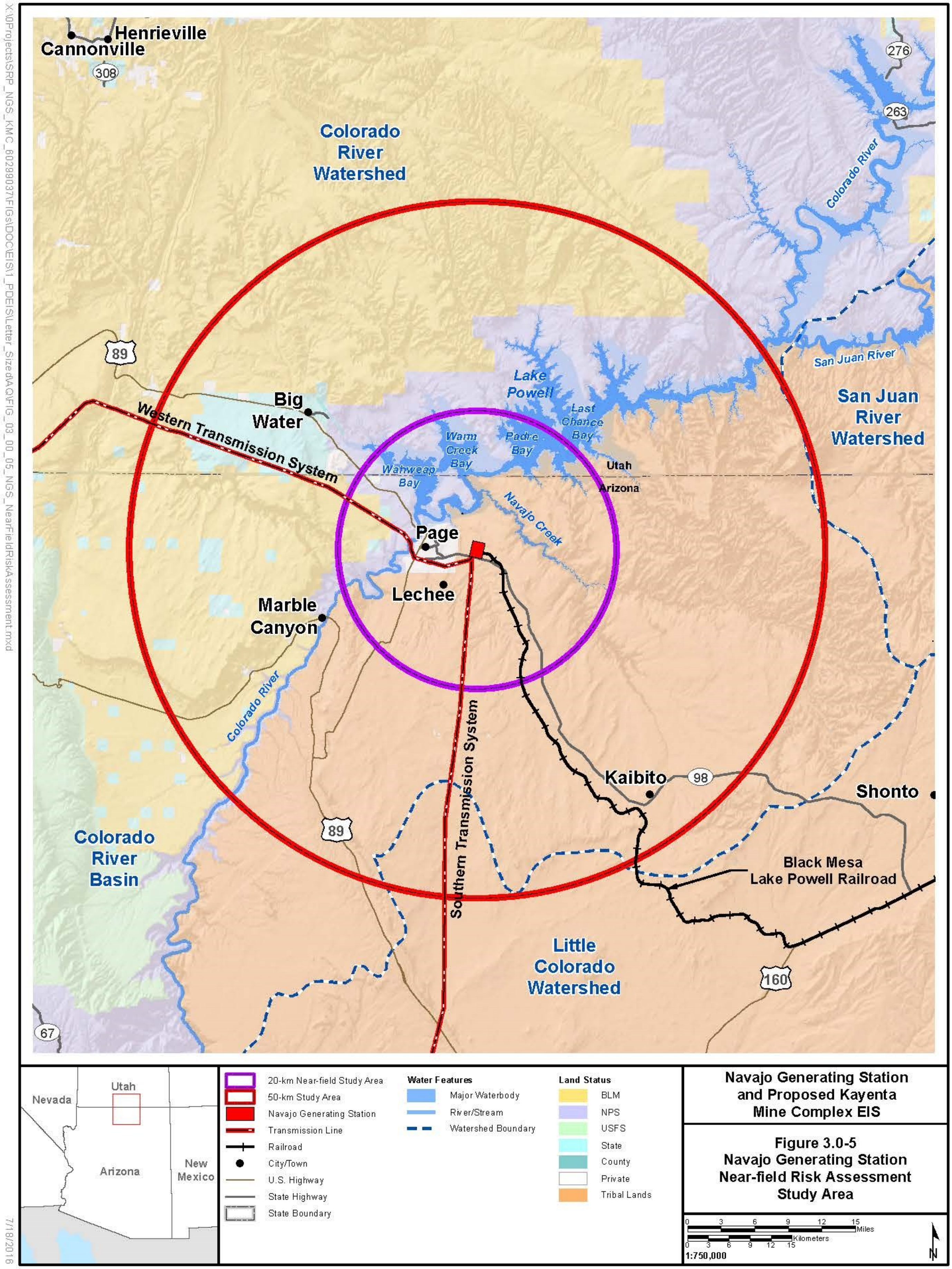
- **Risk Characterization/Uncertainty Analysis.** Risk characterization integrates the problem formulation/hazard identification and exposure/effects assessment phases to develop quantitative estimates of risk. Risk estimates are developed for each receptor and chemical and represented by the hazard quotient for individual chemicals for ecological and human health evaluations. In addition, human health evaluations develop a hazard index for chemicals that do not cause cancer (non-carcinogens) and cancer risk estimates for chemicals with carcinogenic potential (carcinogens). The uncertainty analysis discusses general uncertainties inherent to all risk assessments, as well as site-specific uncertainties related to parameters such as exposure assumptions and/or toxicity information that underlie the risk estimates to provide site-specific context to the risk results.

3.0.3.1 Risk Assessment Study Areas

Five distinct study areas were identified and analyzed for the four ERAs and/or two HHRAs conducted for the project. Different types of air quality dispersion models were used to estimate the deposition rates of trace metals and other hazardous air pollutant compounds in stack emissions and in fugitive dust generated by mining activities within the appropriate modeling domain. The NGS and proposed KMC air dispersion models were coordinated such that combined impacts of both NGS and proposed KMC emissions and deposition were incorporated into the ERAs and HHRAs. The following is a summary of each study area and how it was defined.

3.0.3.1.1 NGS Near-field

The NGS Near-field ERA evaluated a suite of target chemical constituents (chemicals of potential ecological concern) including inorganic chemicals (metals, including arsenic, mercury and selenium) and organic chemicals (e.g., dioxins/furans and polycyclic aromatic hydrocarbons). Among those chemicals of potential ecological concern present in NGS stack emissions, selenium was identified as having the highest rate of deposition (propensity to fall out of the atmosphere) than any other chemicals of potential ecological concern (Ramboll Environ 2016a). Selenium was therefore chosen to represent all other chemicals of potential ecological concern for defining the near-field study area. A conservative soil deposition threshold, or soil concentration at or below which no adverse effects to human health or the environment is expected, was developed based on NGS stack/emission parameters and meteorological considerations using the AERMOD atmospheric dispersion modeling system (Ramboll Environ 2016a). A protective soil deposition rate of 52 micrograms of selenium per square meter of soil per year was estimated and used to determine the study area boundary. This rate is protective of ecological (and human health) receptors exposed to selenium deposited to soil, and receptors present in areas where the deposition rate is lower than this threshold (i.e., further away from stack emissions) are not expected to be adversely affected. Therefore, the study area was determined to be the area within which there is a potential to exceed the threshold assuming continued operation of NGS from 2020 through 2044 (Environ 2014a,b). To ensure that human health and the environment are protected, the defined deposition threshold was conservatively based on 10 percent of the lowest selenium ecological soil screening level (10 percent of 0.52 milligrams selenium per kilogram soil or 0.052) protective of the most sensitive ecological receptor reported in USEPA Guidance (USEPA 2007). Note that a screening level is a numeric standard that allows quick and easy determination of whether concentrations of hazardous chemicals represent a potential risk and/or require further evaluation. This threshold also is protective of human health receptors that have a USEPA Regional Screening Level for selenium of 39 milligrams selenium per kilogram soil (USEPA 2015) that is protective of residential exposure to soil, and is greater than 100-times higher (less conservative) than the ecological soil screening level. The results indicated the deposition area (where selenium deposition exceeds 52 micrograms of selenium per square meter of soil per year) to be within a 16-km radius of the source. The 16-km radius was conservatively rounded upward to a 20-km radius, which is defined as the NGS Near-field study area (**Figure 3.0-5**).



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 3.0-5
Navajo Generating Station Near-field Risk Assessment Study Area

The 20-km extent of the study area was subsequently verified by consideration of soil background data collected within a 20-km radius of NGS (Ramboll Environ 2016f) in combination with the AERMOD data deposition profile for selenium (Environ 2014a). Inclusion of the selenium soil background concentration (representative of both human-caused and natural existing conditions) to develop the threshold level addresses the incremental (annual) deposition of selenium to the environment while also conservatively accounting for the contribution from background conditions. Based on the AERMOD data deposition profile for selenium reported by Environ (2014a) and with consideration of selenium soil background, the selenium deposition threshold protective of ecological and human health receptors was determined to be 325 micrograms selenium per square meter of soil per year. This level was determined without the conservative adjustment by 10 percent because it considered both site-specific AERMOD data (Environ 2014a; Ramboll Environ 2016a) and background soil conditions. The preliminary study area extent (20-km radius from NGS) that was originally applied, used a screening air model without background soil consideration. These results indicated a deposition area of about a 3-km radius from the NGS stacks, well within a 20-km radius study area defined for the NGS.

The NGS Near-field study area was used to evaluate both ecological and human health risk. The remaining extent of the AERMOD domain (i.e., from 20 km to 50 km from NGS) also was considered in the human health evaluation to assess inhalation exposure. Specific details regarding how AERMOD model's predicted output concentrations were used is described within the context of the ERA and HHRA reports. Those reports are briefly described in Section 3.0.2.1 and Section 3.0.2.2, respectively.

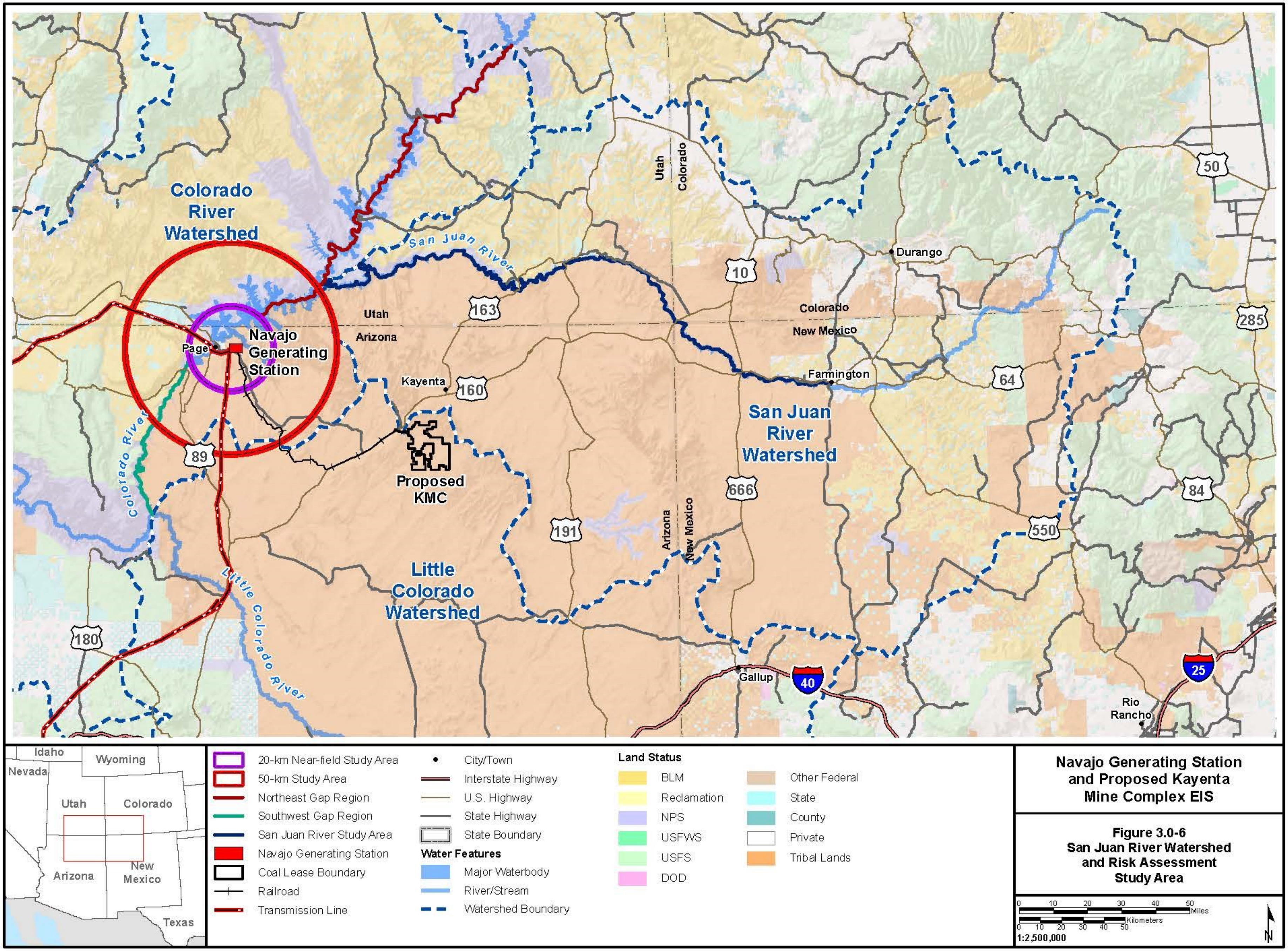
3.0.3.1.2 San Juan River

EPRI conducted a watershed-scale assessment of trace metal deposition and dynamics within the San Juan River watershed attributed to emission of arsenic, mercury, and selenium from three regional power plants (NGS, San Juan Generating Station, and Four Corners Power Plant). Atmospheric modeling of arsenic, mercury, and selenium was conducted using a suite of regional air quality models and the output was incorporated into a watershed biogeochemical cycling and aquatic biota bioaccumulation model to estimate arsenic, mercury, and selenium concentrations in surface water and mercury concentrations in invertebrate and fish tissue. Modeling estimates included contributions of local, regional, and global sources in the San Juan River Basin extending downstream and into the San Juan arm of Lake Powell. **Figure 3.0-6** depicts the San Juan River watershed within the domain of the EPRI model. The methods used to develop the models are summarized in the EPRI report (EPRI 2016). The San Juan River study area was included in the evaluation of ecological risk only because the indirect effects would contribute to and could result in potential cumulative impacts (Ramboll Environ 2016b).

3.0.3.1.3 Gap Regions

Analysis of the Gap Regions (Ramboll Environ 2016c) was conducted to address potential risks to aquatic and aquatic-oriented wildlife in the Colorado River upstream and downstream of Lake Powell, in areas that were not specifically evaluated in the NGS Near-field or San Juan River ERAs. The Gap Regions study area and chemicals of concern (arsenic, mercury, and selenium only) were defined based on consultation with U.S. Fish and Wildlife Service and other cooperating agencies to address habitat for several special status fish species. The two Gap Regions, for which one ERA was prepared, fall outside of the 20-km NGS Near-field study area and San Juan River study area. The two study areas are depicted in **Figure 3.0-7** and include:

- **Northeast Gap Region.** This includes the portion of Lake Powell beyond the 20-km NGS Near-field study area and the Colorado River northeast of Lake Powell upstream to the confluence of the Colorado and Green rivers (approximately 274 km upstream of the Glen Canyon Dam).



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 3.0-6 San Juan River Watershed and Risk Assessment Study Area

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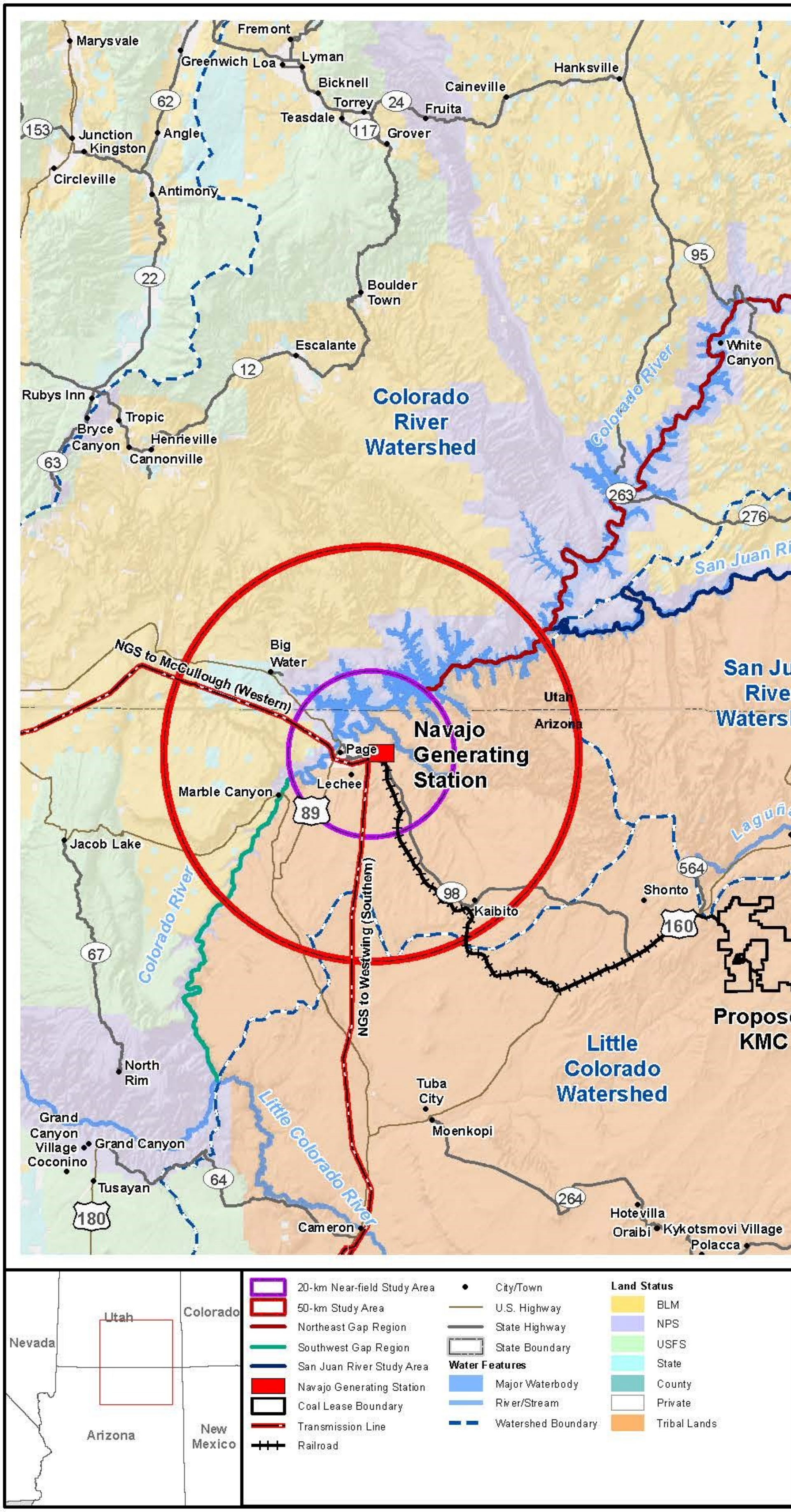

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 3.0-7 Gap Regions and Risk Assessment Study Area

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- **Southwest Gap Region.** This includes the lower Colorado River downstream of the 20-km NGS Near-field study area, from Lees Ferry to the confluence of the Colorado and Little Colorado rivers (approximately 100 km downstream of the Glen Canyon Dam).

The Gap Regions study area was included in the evaluation of ecological risk to account for the indirect effects that potentially add to the cumulative impacts.

3.0.3.1.4 Proposed KMC

The proposed KMC study area was based on consideration of the existing lease property boundaries, the influence of active and proposed future mining activities (deposition area), the presence of human residential areas, and the presence of special status species and important ecological features (Flatirons Toxicology 2015a; Ramboll Environ 2016d). This area includes key ecological habitats (e.g., seeps and springs), soil, sediment, locations of special status species (i.e., Navajo sedge and Mexican spotted owl), and surface water features that may be affected by potential transport off-site (i.e., via overland flow and/or wind-generated erosion, via groundwater and other release and transport mechanisms). The study area boundaries were determined in consultation with cooperating agencies and are depicted in **Figure 3.0-8**.

The proposed KMC study area was determined based on air dispersion and deposition modeling conducted by McVehil-Monnett Associates, Inc. The modeling evaluated air impacts in a 40-km x 40-km grid from the lease permit center of the proposed KMC (McVehil-Monnett Associates, Inc. 2016). The AERMOD and NONROAD air models evaluated the emission/deposition of contaminants from mine operations through 2044 assuming continued mining operations necessary to provide coal for power generation at NGS. The model results indicated that total suspended particulate emissions were the primary source of emission sources at the proposed KMC, which may be generated from mining/pit activities, handling of topsoil, overburden (i.e., soil layer overlying coal deposits) and coal, coal processing, pit reclamation, and road travel. Heavy equipment tailpipe emissions from the mining operations and coal/coal overburden transport were modeled using the NONROAD model (McVehil-Monnett Associates, Inc. 2016) and was identified as a secondary emission source. Assuming a reasonably anticipated future maximum emission scenario (8.1 million tpy, the highest coal production scenario), the extent of impacts from proposed KMC emission sources was determined to be limited to areas within and adjacent to the lease boundary as indicated by selenium deposition contours at 52 micrograms per square meter per year, the threshold that was used in the proposed KMC ERA Study Plan to define the study area. The extent of deposition along with information regarding potential receptors, site-specific exposure scenarios and ecological attributes were used to guide the field sampling effort to obtain data necessary to support both the HHRA and ERA.

3.0.3.2 Ecological Risk Assessments

Four ERAs were conducted to evaluate the potential for adverse effects to ecological receptors. Representative ecological receptors observed or expected to occur locally or regionally were selected to evaluate the potential for adverse effects due to current and/or proposed future operation of NGS and the proposed KMC (and the combined impact of both project components). The biological organisms evaluated included terrestrial wildlife and soil communities (plants and soil invertebrates), aquatic-oriented wildlife, aquatic communities (plants, invertebrates and fish), and specific special status species (e.g., federally endangered or threatened species). The time frame for analysis was 2020–2074 to capture the indirect effects of NGS emissions and other cumulative emissions, accounting for the time it could take NGS and cumulative emissions in 2044 to deposit and move through the various ecosystems. The four assessments conducted include:

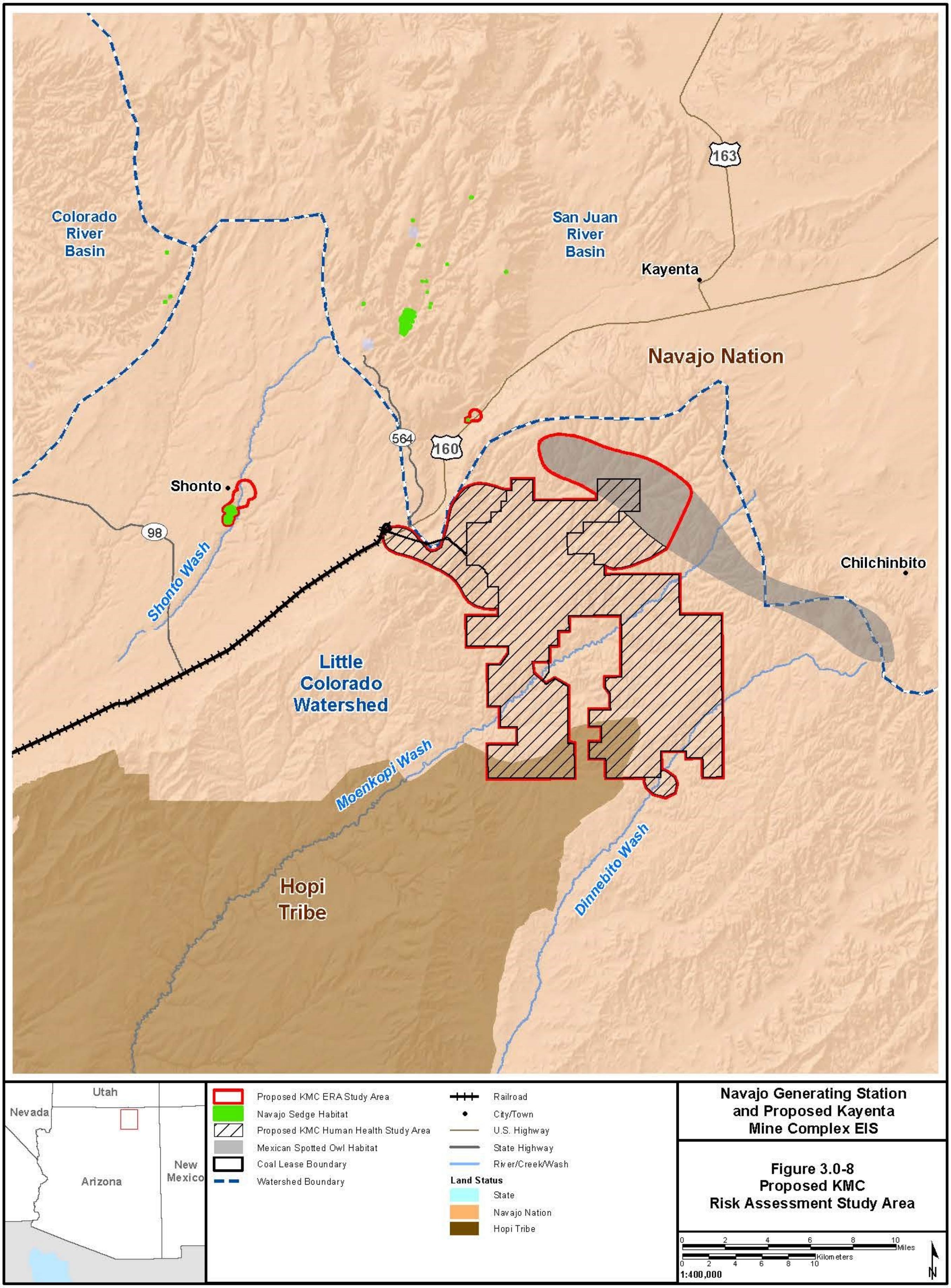

Figure 3.0-8
Proposed KMC
Risk Assessment Study Area

- **NGS Near-field ERA:** The NGS Near-field ERA evaluated existing baseline conditions and potential future environmental conditions in the vicinity of NGS (Ramboll Environ 2016a). Baseline conditions were estimated from soil, surface water and sediment data collected in summer 2014 within the 20-km study area defined for the ERA. These baseline data, especially soil data, are considered representative of naturally occurring constituents, taken together with past cumulative emission/deposition from all potential sources, including local (which includes deposition and accumulation in soil and sediment from NGS historic operations), regional and global. The methods and results of this sampling event were reported in the NGS Near-field Sampling Investigation Report (Ramboll Environ 2016f) and form the basis for defining baseline conditions in this study area. In addition, recent literature data were considered in establishing baseline tissue concentrations for fish species that occur within the study area (Ramboll Environ 2016a). These baseline data, along with NGS emissions and other cumulative emission sources, were used to specifically evaluate the potential ecological risk in terrestrial and aquatic environments from exposure to chemicals present under baseline conditions and under future NGS and other cumulative emission scenarios.

- **San Juan River ERA:** The San Juan River ERA (Ramboll Environ 2016b) evaluated existing baseline conditions and potential future environmental conditions in the San Juan River and the potential for adverse effects to aquatic and aquatic-oriented receptors. The San Juan River ERA (Ramboll Environ 2016b) used results from the EPRI (2016) study to assess the potential future effects to receptors. Baseline conditions in the San Juan River were based on surface water, sediment and fish tissue data obtained from the literature (Ramboll Environ 2016b). EPRI (2016) integrated a multi-scaled air quality model to estimate the contributions of arsenic, mercury, and selenium to the San Juan River watershed from global, regional (western United States), and local sources, especially isolating and analyzing the deposition from NGS, the Four Corners Power Plant, and the San Juan Generating Station. The regional air model was coupled with a watershed biogeochemical cycling and aquatic biota bioaccumulation model to calculate surface water concentrations of arsenic, selenium, and mercury over space and time in the San Juan River Basin extending downstream to the San Juan arm of Lake Powell. The EPRI study also estimated fish tissue and invertebrate concentrations of mercury in federally endangered fish species (Colorado pikeminnow and razorback sucker) over time to 2074. As noted, the EPRI (2016) study was used in the ERA and also in independent analysis in cooperation with the U.S. Fish and Wildlife Service to evaluate the impacts of the project.

- **Gap Regions ERA:** The Gap Regions ERA (Ramboll Environ 2016c) evaluated existing baseline conditions and potential future environmental conditions in areas not specifically addressed by the NGS Near-field ERA or San Juan River ERA. Baseline conditions in the Gap Regions (**Figure 3.0-6**) were estimated from surface water, sediment, and fish tissue data obtained from the literature, and future conditions were based on emission/deposition data from the EPRI (2016) study (Ramboll Environ 2016c). The Gap Regions ERA was included to address U.S. Fish and Wildlife Service's request for impact information on sensitive aquatic species in areas potentially influenced by NGS but not specifically falling within the NGS or San Juan River study areas. The Gap Regions were ultimately defined in consultation with U.S. Fish and Wildlife Service and other cooperating agencies and the ERA evaluated aquatic and aquatic-oriented ecological receptors only, with a focus on special status species occurring in association with the Northeast and Southwest Gap Regions. Chemicals of potential ecological concern were focused on arsenic, mercury, and selenium.

- **KMC ERA:** The KMC ERA evaluated existing baseline conditions and potential future environmental conditions in the vicinity of the proposed KMC (Ramboll Environ 2016d). Baseline conditions were estimated from soil, and sediment data collected in summer 2014 within the study area defined for the ERA and surface water data obtained from the PWCC Historical Water Quality Monitoring Program. These baseline data, especially soil data, are considered representative of past cumulative emission/deposition from all potential sources, including local ground-level emissions (fugitive dusts), and regional and global emission/deposition associated with coal combustion. The methods and results of this sampling event were reported in the proposed KMC Sampling Investigation Report (Ramboll Environ 2016g) and, along with surface water monitoring data provided by PWCC, form the basis for defining baseline conditions in this study area. These baseline data, along with ground-level dust emissions and other cumulative emission sources, were used to specifically evaluate the potential ecological risk in terrestrial and aquatic environments from exposure to chemicals present under baseline conditions, and under future NGS and other cumulative emission scenarios.

The ERAs quantified chemical risk for representative ecological receptors. The receptors were selected based on ecological conceptual site models, which graphically and narratively describe the relationship between potential source, release mechanisms (e.g., aerial deposition or wind-generated dusts), and environmental exposure to potential animal and plant receptors. Risk characterization is the estimation and description of risk based on the exposure and toxicity assessments but also considers the uncertainties associated with the estimation and description of risk (USEPA 1999, 1998, 1997). In accordance with USEPA guidance, two primary estimates of risk screening and refined risk, discussed subsequently were developed for the ERAs to estimate exposure and risk to plants and animals, and used to provide a range of potential risk at NGS and associated facilities and the proposed KMC (Ramboll Environ 2016a,b,c,d).

Due to the nature of the ERAs, in which each considers a baseline scenario as well as future scenarios, all chemicals of potential ecological concern and receptors were retained throughout the ERA process (i.e., no chemicals of potential ecological concern-receptor pairs were dismissed prior to completion of all applicable scenarios) (Ramboll Environ 2016a,b,c,d). This allows for a total cumulative risk estimate that considers baseline, NGS or proposed KMC future contribution and other cumulative sources.

The outcome of the refined evaluation represents a scientific management decision point (USEPA 1997) in which the conclusion of acceptable or unacceptable ecological risk is used to guide risk management decisions or define additional data needs to further characterize risk.

3.0.3.2.1 ERA Process and Applicability to the EIS Process

Screening and refined evaluations in the context of the overall ERA process, key risk assessment concepts, and the applicability of the ERAs to the EIS process are discussed in this section. Additional information summarizing methods and results of the ERAs is provided in **Appendix 3RA** and full details are provided in each of the ERA reports (Ramboll Environ 2016a,b,c,d).

For ecological community-level receptors, the potential risk is estimated by direct comparison of measured concentrations of chemicals of potential ecological concern in soil, sediment, surface water, or fish tissue to their respective screening level or benchmark toxicity values, collectively referred to as ecological screening values. These comparisons apply to terrestrial plants and invertebrates exposed to soil, and aquatic organisms (i.e., fish, other aquatic animals, and aquatic plants) exposed to surface water and/or benthic zone organisms exposed to sediment.

The exposure assessment presents the assumptions and parameters used to develop estimates of exposure. Per USEPA ERA guidance (USEPA 1998, 1997), the ERA is an evaluation based on generally conservative assumptions and is intended to eliminate from further study, chemicals of potential ecological concern having no potential to cause risk, and identify those chemicals of potential ecological concern and receptors that require further evaluation. Risk assessment is typically conducted in a tiered, step-wise manner to maximize the use of available site and receptor-specific information while providing the opportunity, with each tier of evaluation, to reduce and minimize uncertainties that are inherent in the ERA process. As indicated above, the screening evaluation is the first tier of the process and provides a conservative estimate of exposure based on maximum environmental chemicals of potential ecological concern concentrations and the assumption that a given receptor is exposed to such concentration for its entire life. This exposure assumption is generally not realistic in nature because it assumes a given receptor is exposed continuously to only a maximum concentration, even though in general, wildlife and associated plant and animal communities are typically exposed over a wider range or habitat within which their exposure is best represented as an average. Therefore, this first tier of the ERA process is intended to eliminate chemicals (and receptors) for which exposure is considered to have no effect. The refined evaluation allows for “refinement” of chemicals of potential ecological concern identified in the initial screening (USEPA 1998, 1997) and is focused on identification and characterization of current and future risk using site-specific assumptions regarding exposure. For the NGS ERAs, the key exposure assumption that defines the screening and refined evaluations is the chemicals of potential ecological concern concentration or exposure point concentration that is used (soil, surface water, sediment or fish tissue concentration to which ecological receptors are exposed). Exposure point concentrations are estimates of the representative exposure concentration of chemicals of potential ecological concern in a given study area. In the screening evaluation, the exposure point concentration is the maximum detected concentration. In the refined evaluation, the 95 percent upper confidence limit of the arithmetic mean for soil, surface water, sediment and fish tissue is used if it can be calculated. The 95 percent upper confidence limit of the arithmetic mean is calculated using USEPA’s statistical tool ProUCL version 5.0.00 (USEPA 2013) wherever the number of sample points (i.e., six or more samples) and chemicals of potential ecological concern detections were sufficient to compute the 95 percent upper confidence limit of the mean; otherwise, the maximum detected concentration was applied in the refined evaluation. A simple arithmetic average concentration also may be considered in the refined evaluation as an additional line of evidence to characterize exposure.

The toxicity assessment identifies appropriate toxicity data for use in the ERA and evaluates toxicity and provides other effects information to correlate impairment of health exposure to ecological receptors. Toxicity reference values and ecological screening values correlate a specified effect to a given chemical concentration and are used to characterize potential ecological effects. The toxicity data used to evaluate ecological risks resulting from chemical exposure are available in ecological risk assessment guidance and state, federal, and literature sources and typically are derived from single-chemical toxicity studies. The toxicity data and exposure parameters used to develop risk estimates were presented in each of the ERAs developed for this project (Ramboll Environ 2016a,b,c,d). The toxicity data considered include ecological screening values that are based on no observed effect concentrations and are used to evaluate biological communities (aggregate populations of organisms), and no observed adverse effect level toxicity reference values that are used to evaluate wildlife. In addition, fish tissue critical body residues are used to evaluate toxicity to fish. The critical body residue is a fish tissue concentration that is protective of fish health. Toxicity data used for the screening evaluation are generally based on no effect data (no observed effect concentration/no observed adverse effect level) that are considered protective of individual organisms and, by default, organism populations. For the refined evaluation, a lowest observed adverse effect level toxicity reference value also may be considered if risk thresholds were exceeded using the no observable adverse effect level. These latter toxicity data are considered protective of organism populations.

The following summarizes the key exposure media and exposure and toxicity assumptions applied for all ERAs in each tier of evaluation:

- Screening Evaluation – uses the maximum detect concentration in soil, surface water, sediment and fish tissue (where available), no observed effect concentration/no observed adverse effect level toxicity data, and assumes all mammals and most birds are present within a defined study area for their entire life (area use is 100 percent). Because the screening evaluation uses maximum concentrations of chemicals of potential ecological concern and conservative exposure parameters it provides a conservative (overly protective) estimate of exposure.
- Refined Evaluation – uses the 95 percent upper confidence limit (or maximum detected concentration if a 95 percent upper confidence limit could not be calculated) in soil, surface water, sediment and fish tissue (where available), no observed effect concentration/no observed adverse effect level toxicity data, and assumes all mammals and most birds are present within a defined study area for their entire life (area use is 100 percent). Lowest observed effect concentration/lowest observed adverse effect level toxicity data also are considered on a case

by case basis, and arithmetic average concentrations also are considered in the refined evaluation.

In both tiers of evaluation, for those wildlife receptors (birds) that have large feeding ranges (larger than the study area) and/or migrate in/out of a given study area seasonally, an area use factor and exposure duration, respectively, are considered and the same values used for screening and refined evaluations. In addition, uptake factors (used to estimate wildlife tissue concentration of chemicals of potential ecological concern from soil, surface water and/or sediment) are based on estimated average exposure, and receptor-specific life history parameters (e.g., body weight, food intake rate, dietary preference and components, feeding range and exposure duration/migration) are the same for both screening and refined evaluations.

Risk estimation uses quantitative methods to evaluate the potential for risk, which are presented as screening level hazard quotients (hazard $quotient_{max}$) and refined hazard quotients (hazard $quotient_{refined}$). For screening and refined evaluations, risk estimates are developed for each receptor using the defined measures of exposure (medium-specific exposure point concentrations and receptor exposure parameters) and effect (chemical-specific toxicity reference values) for each exposure scenario. For wildlife evaluations, toxicity reference values based on no observed adverse effect levels are considered for both the maximum exposure scenario risk estimates (no observed adverse effect level hazard $quotient_{max}$) and refined exposure scenario estimates (no observed adverse effect level hazard $quotient_{refined}$). For the refined exposure scenario, a lowest observed adverse effect level also may be considered if further evaluation is warranted (lowest observed adverse effect level hazard $quotient_{refined}$). Refined risk description considers the quantitative risk estimates and, along with other lines of evidence (e.g., habitat and vegetation quality, consideration of background conditions, receptor diet) and potentially affected receptor groups, serves to identify chemicals for additional consideration in additional tiers of evaluation and/or for consideration for risk management. For special status species (especially federal or state listed species), hazard quotients based on toxicity data protective of individual organisms (no observed effect concentration or no observed adverse effect level) are most applicable and so no observed adverse effect level hazard $quotient_{refined}$ and no observed adverse effect level hazard $quotient_{max}$ are relevant for these receptors. For non-special status species, hazard quotients based on toxicity data protective of organism population (lowest observed adverse effect level or lowest observed effect concentration) are most relevant.

The hazard quotient is a unitless value that relates the measured (or modeled using uptake factors) concentration in site media (e.g., soil) to a known literature-based toxicity level expressed in the same units of measure (e.g., milligrams per kilogram) and is calculated as follows:

$$HQ = \frac{Maximum\ Detected\ Concentration\ or\ 95\%\ UCL}{Ecological\ Screening\ Value\ (ESV)}$$

Chemical concentrations in excess of literature-based toxicity levels indicate a potential for adverse effects to a given community. In general, media-specific concentrations less than or equal to the applicable ecological screening value (typically based on a no effect level) are unlikely to result in impairment of health for ecological receptors and can be effectively eliminated from further consideration. The risk estimates for community level receptors (organism populations), based on comparison of applicable ecological screening values (protective of organism health) to medium-specific concentrations, may be interpreted as follows:

- HQ_{max} less than or equal to 1
  - Ecological risk is highly unlikely
  - No further concerns

- $HQ_{refined}$ less than 1 but HQ_{max} greater than 1
  - Ecological risk to individual organisms possible
  - Ecological risk to organism populations is unlikely or negligible
  - Evaluate other lines of evidence (e.g., background conditions) to draw conclusions
- $HQ_{refined}$ greater than 1
  - Ecological risk to community/population may be possible
  - Evaluate other lines of evidence (e.g., background conditions) to draw conclusions

For birds and mammals, the risk estimate is based on a hazard quotient defined as the ingested dietary dose (i.e., the intake of chemicals in soil or sediment, food, and water) divided by the chemical-specific toxicity reference value expressed in the same units of measure (i.e., milligrams food/water per kilogram body weight per day):

$$HQ = \frac{Dietary\ Dose}{Toxicity\ Reference\ Value}$$

Food web biotransfer from contaminated media to biota is based on assumptions that generally result in conservative estimates of exposure dose.

For bird and mammal evaluations, the hazard quotient may be interpreted as follows:

- No observed adverse effect level hazard $quotient_{max}$ is less than or equal to 1
  - Ecological risk is highly unlikely.
  - No further concerns.
- No observed adverse effect level hazard $quotient_{max}$ greater than 1 but no observed adverse effect level hazard $quotient_{refined}$ less than 1
  - Ecological risk to individual organisms possible.
  - Ecological risk to organism populations is unlikely or negligible.
  - Evaluate other lines of evidence (e.g., background concentrations) to draw risk conclusions.
- No observed adverse effect level $HQ_{refined}$ greater than 1 but lowest observed adverse effect level $HQ_{refined}$ less than 1
  - Ecological risk to individual organisms possible
  - Ecological risk to population is low or negligible
  - Evaluate other lines of evidence (e.g., background conditions) to draw conclusions
- Lowest observed adverse effect level hazard $quotient_{refined}$ greater than or equal to 1
  - Ecological risk may be present.
  - Proceed to risk management and/or consider additional lines of evidence and/or studies to further refine risk estimate.

The hazard quotient is not a predictor of risk but rather is a tool used to screen out chemical exposure to receptors where there is no harm indicated, and to identify chemicals for which additional evaluation may be required (Allard et al. 2009; USEPA 1997). The numeric HQ estimates generated also are considered, where applicable, with other lines of evidence to reduce the uncertainty in the estimate to draw conclusions regarding risk. Lines of evidence may include, but are not limited to, consideration of naturally occurring and/or human-caused background conditions, review of presence, absence and/or quality of habitat, consideration of supplemental toxicity data. Such lines of evidence are discussed in detail in the uncertainty analysis of the risk assessment reports (Ramboll Environ 2016a,b,c,d). An overview of key uncertainties is provided in **Appendix 3RA**.

For purposes of EIS analysis, the predicted hazard quotient values for defined representative ecological receptors (species or species groups) are used as indicators to determine whether risk is negligible or possible. Other factors influencing the health of individual species populations also are considered in the impact analysis. It is important to reiterate that all chemicals of potential ecological concern and receptors were carried through the entire ERA process, which includes evaluation of multiple primary scenarios: baseline, NGS or proposed KMC emissions, and other cumulative sources. So, the HQs presented in the subsequent resource-specific sections (wildlife, vegetation, and aquatic resources) are focused to the receptors and chemicals of potential ecological concern where HQs, considering all three scenarios together (total cumulative), indicate that risk is possible or unknown. Each scenario is then discussed as it pertains to the Affected Environment and Environmental Consequences discussions in Sections 3.8 through 3.13. **Appendix 3RA** provides an overview summary the ERA process and resulting risk estimates for each ERA conducted.

3.0.3.3 Human Health Risk Assessments

Human receptors could be exposed to project-related residual chemicals present in air, soil, water, sediment, and food in the area under current conditions. The sources of these chemicals in environmental media may include past and future NGS and mining operations; regional emission sources including but not limited to the Four Corners Power Plant and San Juan Generating Station; municipal, industrial and agricultural emissions and/or runoff; global emission sources; and naturally occurring conditions.

Two HHRAs were conducted to evaluate the potential for adverse effects to human populations that are present locally or regionally that could be affected by current or proposed future operation of NGS and the proposed KMC. The study areas for the HHRAs include the area up to 50 km from the NGS and up to a distance of approximately 50 km from the center of the proposed KMC lease permit boundary, as reflected in the dispersion modeling that was used to evaluate impacts. The NGS and proposed KMC air models were used as inputs to calculate ambient air concentrations and deposition for the respective projects. In addition, the combined impacts of NGS and proposed KMC operations on each other were analyzed and considered.

For both the NGS and proposed KMC, the HHRA process for identifying COPCs focused on substances associated with facility operations, standard risk-based environmental concentrations of concern, and potential background sources of the substances (e.g., typical environmental concentrations of naturally occurring metals). For the NGS HHRA, the selected COPCs are those typically associated with coal-fired power generation (including both stack and fugitive emissions) as well as diesel vehicle traffic. The KMC HHRA focused on COPCs generated during coal mining, handling, and transport by diesel trucks and other vehicles. For both facilities, the list of COPCs included polycyclic aromatic hydrocarbon compounds, diesel particulate matter, criteria air pollutants and approximately 20 metals. The NGS HHRA also considered dioxins and furans, volatile compounds and acid gases (Gradient 2016).

The human health risk assessments included:

- **NGS HHRA:** This HHRA evaluated existing baseline conditions (2019) and prospective future environmental conditions through 2044 for ambient air impact and through 2074 for deposition impacts in the vicinity of NGS (Ramboll Environ 2016e,f). The HHRA was conducted to specifically evaluate potential risk to human health from potential exposure to chemicals present in environmental media and those dispersed from stack emissions and other NGS sources within the area identified by air dispersion modeling (AERMOD) (i.e., within a 50 km radius of NGS), proposed KMC emissions, and regional/global sources.

- **KMC HHRA:** This HHRA evaluated existing baseline conditions (2019) and prospective future environmental conditions in the vicinity of the proposed KMC (Flatirons Toxicology, Inc. 2015a,b). The HHRA was conducted to specifically evaluate the potential for adverse effects to human health from potential exposure to existing chemicals currently present in environmental media and those potentially dispersed from modeled ground level emission sources associated with proposed future mining operations through 2044 plus two years of active reclamation work, NGS stack and secondary emissions, and regional/global sources.

For these evaluations, background and incremental (i.e., risk above expected background) lifetime cancer risks and non-cancer hazard indices were evaluated for individuals who may reside, work, or recreate within 50 km of NGS, and individuals that reside in the vicinity of the proposed KMC. Each risk assessment was performed as a separate evaluation with a unique set of receptors and sampling data, and evaluated adverse health endpoints for baseline (i.e., currently existing conditions in the vicinity of the facilities), Proposed Action (i.e., conditions predicted in the vicinity of the facilities as a result of future facility operations and emissions), combined impacts (NGS + proposed KMC, proposed KMC + NGS), and other cumulative sources (i.e., potential exposures and risks associated with other regional and global sources of three specific chemicals–arsenic, mercury and selenium).

3.0.3.3.1 HHRA Process and Applicability to the EIS Process

The hazard identification and exposure and toxicity assessments present the exposure and toxicity data necessary to develop risk estimates in the risk characterization step. The HHRA calculates two types of risk estimates for each receptor population relevant for evaluation: incremental lifetime cancer risks and non-cancer hazard quotients for each COPC and receptor.

For carcinogens (known or potential cancer-causing chemicals), the risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure over some defined exposure interval (e.g., an estimated exposure interval over a lifetime of 70 years). Calculated results (cancer risk estimates) are compared to USEPA acceptable incremental target cancer risks, with a cancer incidence (i.e., rate of occurrence) of one in ten thousand (i.e., 1/10,000) to an incidence of one in one million (i.e., 1/1,000,000) (USEPA 1990). Cancer risk of one in one million means that in a population of one million people, not more than one additional person would be expected to develop cancer as the result of the exposure to a given substance causing that risk. One in one million risk of cancer from life-long exposure to a hazardous chemical represents an “acceptable risk” level because the risk is comparable but below the overall lifetime probability of an individual developing cancer in the United States of 1 in 2 for males and 1 in 3 for females (American Cancer Society 2015). Individual chemical cancer and/or cumulative cancer risks (i.e., sum of cancer risk for multiple chemicals) are calculated, and cancer risks exceeding one in ten thousand generally are considered unacceptable. This typically would warrant remedial action to reduce or control potential risk (USEPA 1991). Individual COPC cancer risks are calculated as the total intake (e.g., via diet, and/or dermal exposure) times the cancer toxicity value that is applicable to the pathway of exposure (i.e., cancer slope factor for dietary and dermal exposure) (USEPA 2004). Based on USEPA guidance (USEPA 2009), air concentrations of COPCs rather than COPC intakes were used to evaluate inhalation risk. The quantitative cancer risk calculations for the air inhalation route of exposure integrate exposure concentrations and toxicity. The general equation for cancer risk is:

$$Cancer\ Risk = Intake\ x\ Cancer\ Toxicity\ Value$$

The individual COPC cancer risks are then added together to obtain a cumulative cancer risk estimate for each relevant receptor group (e.g., residents).

Quantitative evaluation of potential non-cancer human health risk is determined by comparing the actual level of exposure to a chemical (intake), to a level of exposure that is not expected to cause any adverse effects (e.g., asthma, birth defects, nervous system disorders), even in the most susceptible populations. These non-cancer, no effect levels are referred to as either reference doses (based on exposure in food or water) or reference concentrations (based on exposure in air) to determine a hazard quotient, a quantitative estimate of non-cancer health risks. The quantitative non-cancer risk calculations for the air inhalation route of exposure integrate exposure concentrations and toxicity rather than COPC intakes. The general equation for noncancer risk is:

$$HQ = \frac{Intake}{Reference\ Dose\ or\ Reference\ Concentration}$$

A hazard quotient is derived for each COPC. The hazard quotients for each COPC are then summed to derive a cumulative hazard index (HI) for all chemicals for each exposure pathway as well as a total HI for all exposure pathways. If a hazard index is less than 1, then the exposures are considered to be acceptable, i.e., no adverse human health effects are expected to occur, for non-cancer risk and no further risk evaluation is warranted. The hazard index is calculated using the following equation:

$$HI = HQ_{COPC1} + HQ_{COPC2} + HQ_{COPC3...}$$

When a hazard index exceeds 1, a target organ analysis is performed. A target organ is the primary or most sensitive organ (e.g., liver, kidney, or lung) where a chemical causes non-cancer toxic effects. A target organ analysis evaluates chemicals that have similar modes of toxicological action or similar impacts on an organ or system of the body. Such chemicals are grouped together to calculate a target organ-specific hazard quotient/hazard index. If the hazard quotient/hazard index is less than 1 for a given target organ, then adverse health effects would not be expected and the analysis is complete. Calculating risk based on a target organ analysis reduces the possibility of overestimating risk by summing hazard quotients for a mixture of chemicals that are not expected to induce the same types of effects on a specific target organ.

For purposes of EIS analysis, the estimated hypothetical cancer risk, hazard quotient and hazard index values for different exposed members of the public are used as indicators of acceptable or unacceptable risk. Other factors influencing the health of individuals and groups of people also are considered in the impact analysis.

3.0.3.4 References

American Cancer Society. 2015. Internet website: www.cancer.org . Accessed July 20, 2016.

Allard, P., A. Fairbrother, B. K. Hope, R. N. Hull, M. S. Johnson. L. Kapustka, G. Mann, B. McDonald, and B. E. Sample. 2009. Recommendations for the Development and Application of Wildlife Toxicity Reference Values. Integrated Environmental Assessment and Management 6:28-37.

Bureau of Land Management (BLM). 2015. TransWest Express Transmission Project. Final Environmental Impact Statement. BLM/WY/PL-15/012+5101, DOE/EIS-0450. April 2015.

Bureau of Land Management (BLM). 2012. Draft Environmental Assessment for the Southern Nevada Intertie Project. Las Vegas Nevada Field Office. DOI-BLM-NV-S0101-2010-0091-EA. May 2012. Internet website: http://www.blm.gov/style/medialib/blm/nv/field_offices/las_vegas_field_office/environmental_assessments/snip_project_ea.Par.6021.File.dat/SNIP%20Draft%20EA_2012May30.pdf. Accessed August 2, 2016.

Environ. 2014a. Near-field Air Dispersion and Deposition Modeling Protocol for Navajo Generating Station National Environmental Policy Act Environmental Impact Statement and Endangered Species Act Compliance. Draft Report prepared for Salt River Project. April 2014.

Environ. 2014b. Near-Field Field Sampling Plan. Salt River Project-Navajo Generating Station, Page, Arizona. Revision 1. July 2014.

Electric Power Research Institute (EPRI). 2016. A Case Study Assessment of Trace Metal Atmospheric Emissions and their Aquatic Impacts in the San Juan River Basin. Phase 2: Navajo Generating Station. 3002006244. R. Goldstein and L. Levin. Final Report. April 2016.

Flatirons Toxicology, Inc. 2015a. Draft Kayenta Mine Complex Human Health Risk Assessment. Revision E. Prepared for Peabody Western Coal Company, Flagstaff, Arizona. December.

Flatirons Toxicology, Inc. 2015b. Human Health Risk Assessment Work Plan for Kayenta Mine Complex. National Environmental Policy Act, Environmental Impact Statement Draft, Revision E. January 2015.

Gradient. 2016. Supplemental Human Health Impacts Information for the Environmental Impact Statement Addressing the Navajo Generating Station/Kayenta Mine Complex Project. Prepared for: Salt River Project, Tempe, Arizona. March 31, 2016.

Lehn, R. 2016. Personal communication regarding KMC acreages between R. Lehn, Director Engineering Services, Peabody Southwest Operations, and S. Ellis, AECOM. May 6, 2016.

McVehil-Monnett Associates, Inc. (MMA). 2016. Kayenta Mine Complex Air Quality Modeling Analyses (Final draft). Report to Peabody Energy. 353 pp. January.

Office of Surface Mining Reclamation and Enforcement (OSMRE). 2015. Record of Decision, Four Corners Power Plant and Navajo Mine Energy Project. July 14, 2015.

Public Service New Mexico (PNM). 2015. A Forward-Looking Plan to Comply with a Federal Visibility Rule. Fact Sheet. Internet website: https://www.pnm.com/documents/396023/440009/San+Juan+plan_fact+sheet.pdf/a37f9be1-f592-4437-b98b-54414ad3fff2. Accessed August 2, 2016.

Peabody Western Coal Company (PWCC). 2016. 2015 Reclamation Status and Monitoring Report for the Black Mesa and Kayenta Mine. May 2015.

Ramboll Environ. 2016a. DRAFT FINAL NGS Near-Field Ecological Risk Assessment Environmental Impact Statement Final Report for the Navajo Generating Station. Version 2. March 2016.

Ramboll Environ. 2016b. DRAFT FINAL NGS San Juan River Ecological Risk Assessment Environmental Impact Statement Summary Report for the Navajo Generating Station. April 2016.

Ramboll Environ. 2016c. DRAFT FINAL NGS Gap Region Ecological Risk Assessment Environmental Impact Statement Final Report for the Navajo Generating Station. March 2016.

Ramboll Environ. 2016d. DRAFT FINAL Ecological Risk Assessment, Environmental Impact Statement Ecological Risk Assessment Report for the Kayenta Mine Complex. April 2016.

Ramboll Environ. 2016e. DRAFT FINAL Human Health Risk Assessment, the Navajo Generating Station. January 2016.

Ramboll Environ. 2016f. FINAL NGS Sampling Investigation Report, Salt River Project – Navajo Generating Station. Revision 1. March 2016.

Ramboll Environ. 2016g. FINAL KMC Sampling Investigation Report, Salt River Project – Kayenta Mine Complex. April 2016.

U.S. Bureau of Reclamation (Reclamation). 2009. Record of Decision for the Navajo-Gallup Water Supply Project Planning Report and Final Environmental Impact Statements. September

U.S. Bureau of Reclamation (Reclamation) and National Park Service (NPS). 2015. Glen Canyon Dam Long-Term Experimental and Management Plan, Draft Environmental Impact Statement. December 2015.

U.S. Environmental Protection Agency (USEPA). 2016. Post-Gold King Mine Release Incident: Conceptual Monitoring Plan for Surface Water, Sediments, and Biology. Issued March 2016. https://www.epa.gov/sites/production/files/2016-03/documents/post-gkm-final-conceptual-monitoring-plan_2016_03_24_16.pdf.

U.S. Environmental Protection Agency (USEPA). 2015. Regional Screening Levels for Chemical Contaminants at Superfund Sites. Internet website: https://www.epa.gov/risk/regional-screening-levels-rsls. Accessed August 2, 2016.

U.S. Environmental Protection Agency (USEPA). 2013. ProUCL Version 5.0 Technical Guide. Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations. EPA/600/R-07/041. September 2013. U.S. Environmental Protection Agency, Office of Research and Development. Internet website: http://www.epa.gov/osp/hstl/tsc/PrpUCL_v5.0_user.pdf. Accessed July 16, 2016.

U.S. Environmental Protection Agency (USEPA). 2009. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment). Final. January.

U.S. Environmental Protection Agency (USEPA). 2007. Ecological Soil Screening Levels for Selenium: Interim Final. OSWER Directive 9285.7-72, Revised. March.

U.S. Environmental Protection Agency (USEPA). 2005. Human Health Risk Assessment Protocol (HHRAP) for Hazardous Waste Combustion Facilities, Final. EPA 520-R-05-006: Solid Waste and Emergency Response, Washington, D.C.

U.S. Environmental Protection Agency (USEPA). 2001. The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments. OSWER, Eco Update. Publication 9345.0-14, EPA 540/ F-01/014. June.

U.S. Environmental Protection Agency (USEPA). 2004. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final. EPA/540/R/99/005: Office of Emergency and Remedial Response. Washington, D.C.

U.S. Environmental Protection Agency (USEPA). 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities (Volume Three). EPA 530-D-99-001A. Office of Solid Waste, Washington D.C. August.

U.S. Environmental Protection Agency (USEPA). 1998. Guidelines for Ecological Risk Assessment. Risk Assessment Forum, Washington, D.C. EPA/630/R-95/002F. April.

U.S. Environmental Protection Agency (USEPA). 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments: Interim Final. OSWER 9285.7-25, EPA 540-R-97-006. June.

U.S. Environmental Protection Agency (USEPA). 1991. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions, Office of Solid Waste and Emergency Response, OSWER Directive 9355.0-30, April 22, 1991.

U.S. Environmental Protection Agency (USEPA). 1990. National Oil and Hazardous Substances Pollution Contingency Plan; Final Rule. Thursday, March 8, 1990; Volume 55, Number 46, 55 FR 8666. NCP-R2TA-1-2.

U.S. Environmental Protection Agency (USEPA). 1989. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A). Interim Final. EPA/540/1-89/002: Office of Emergency and Remedial Response. Washington, D.C.

U.S. Fish and Wildlife Service (USFWS). 2015. Biological Opinion for Four Corners Power Plant and Navajo Mine Energy Project. April 8, 2015. Internet website: http://www.wrcc.osmre.gov/initiatives/fourCorners/documents/FC_040915-FINALBiOpFCPP-NMEPARMS.pdf. Accessed August 2, 2016.

U.S. Fish and Wildlife Service (USFWS). 2009. Endangered Species Act – Section 7 Consultation. Final Biological Opinion. Navajo-Gallup Water Supply Project New Mexico.

U.S. Fish and Wildlife Service and National Marine Fisheries Service (USFWS-NMFS). 1998. Endangered Species Consultation Handbook. Procedures for Conducting Consultation and Conference Activities under Section 7 of the Endangered Species Act. March 1998.

Utah Department of Environmental Quality, Water Quality. 2016. Evaluation of UDEQ Water Quality Data Collected during Spring Runoff following the Gold King Mine Release. Data Collected: February 16, 2016 – June 6, 2016. Issued June 21, 2016. http://www.deq.utah.gov/Topics/Water/goldkingmine/docs/2016/screening-value-analysis-surface-water-06212016.pdf.

Utah Department of Environmental Quality, Water Quality. 2015. Evaluation of UDEQ Water Quality Data Collected in Response to the Gold King Mine Release. Data Collected: August 8, 2015–October 25, 2015. Issued February 10, 2016. http://www.deq.utah.gov/Topics/Water/goldkingmine/docs/2016/02Feb/UDEQ-Screening-Value-Analysis-Surface-Water-2016-08-02.pdf.

Appendix 3RA

Summary of Risk Assessments Conducted in Support of the NGS-KMC EIS

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Section 3.1

Air Quality

Acronyms and Abbreviations

$\mu g/m^3$	micrograms per cubic meter
1969 Lease	Navajo Project Indenture of Lease
As	arsenic
BART	Best Available Retrofit Technology
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BM&LP Railroad	Black Mesa & Lake Powell Railroad
BO	Biological Opinion
CAMx	Comprehensive Air Quality Model with Extensions
CAP	Central Arizona Project
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO	carbon monoxide
CO_2	carbon dioxide
Co-tenants	Salt River Project, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company
Development Fund	Lower Colorado River Basin Development Fund
EIS	Environmental Impact Statement
ERA	Ecological Risk Assessment
ESA	Endangered Species Act of 1973
HAP	Hazardous Air Pollutant
Hg	mercury
HHRA	Human Health Risk Assessment
kg	kilogram
km	kilometer
KMC	Kayenta Mine Complex
kV	kilovolt
kW	kilowatt
MW	megawatt
NAAQS	National Ambient Air Quality Standards
N-Aquifer	Navajo Aquifer
NEPA	National Environmental Policy Act of 1969, as amended
NGS	Navajo Generating Station
NGS Participants	U.S. (Reclamation), Salt River Project, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company
NHPA	National Historic Preservation Act
NNEPA	Navajo Nation Environmental Protection Agency
NO_2	nitrogen dioxide
NO_3	nitrate
NO_X	oxides of nitrogen

OSMRE	Office of Surface Mining Reclamation and Enforcement
PFR	Partial Federal Replacement
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter of 10 microns or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 microns or less
ppb	parts per billion
ppm	parts per million
PWCC	Peabody Western Coal Company
Reclamation	U.S. Bureau of Reclamation
ROW	Right-of-way
Se	selenium
SCR	Selective catalytic reduction
SO_2	sulfur dioxide
SO_4	sulfate
SRP	Salt River Project Agricultural Improvement and Power District
STS	Southern Transmission System
tpy	tons per year
U.S.	United States
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound
WTS	Western Transmission System

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3.1 Air Quality

Proposed continued Navajo Generating Station (NGS) operations and mining activities at the proposed Kayenta Mine Complex (KMC), and alternatives were evaluated against established air quality standards, air quality related values, and compared to the No Action Alternative. The regulatory framework, existing conditions, and environmental effects of the Proposed Action and action alternatives and cumulative impacts related to air quality are addressed in this section. In addition, issues raised in scoping and through other avenues were analyzed.

Air quality characterization includes a review of past and present emissions within the study area. The baseline air quality conditions are portrayed based on recent air quality monitoring data collected in the study area including data on visibility, mercury, and acid deposition. The environmental consequences of the Proposed Action were developed from a set of analyses beginning with a presentation of emissions associated with NGS and the proposed KMC as well as support operations. The emissions for the Proposed Action 3-Unit Operation and 2-Unit Operation at NGS and the associated mining operations (8.1 million tons per year [tpy] and 5.5 million tpy) at the proposed KMC are provided and compared. For each of those operations, a dispersion model and/or a photochemical grid model was used to estimate impacts on air quality, atmospheric depositions of trace metals and other compounds, and acid deposition at Class I areas. The BART analysis conducted by USEPA was used to summarize impacts on regional haze at Class 1 areas.

For the air quality and deposition analyses, the baseline or background conditions were considered and the modeled impacts were added to those conditions to depict the environmental consequences of the Proposed Action and action alternatives. Impacts at the proposed KMC also were analyzed at residences both within the mine lease area and in the immediate vicinity of the proposed KMC. A comparative impact analysis is provided for Proposed Action operations and action alternatives. The deposition and air quality impacts related to chemicals of concern were used as a basis for the ecological risk assessments and the human health risk assessments. Cumulative impacts and the No Action Alternative were also analyzed.

3.1.1 Regulatory Framework

The Clean Air Act of 1970, and its amendments in 1977 and 1990 (referred to collectively as the Clean Air Act), establishes regulatory framework that protects ambient air quality and air quality-related values, requires installation of stringent control technologies, limits emissions to the atmosphere, and provides mechanisms to ensure monitoring and compliance. The U.S. Environmental Protection Agency (USEPA) promulgates regulations to implement the Clean Air Act, and delegates various responsibilities to state and tribal governments.

3.1.1.1 Ambient Air Quality Standards

The Clean Air Act requires establishment of National Ambient Air Quality Standards (NAAQS) for criteria air pollutants across the U.S., including primary standards to protect the health of the citizens and secondary standards to protect other public welfare-related values. The Clean Air Act requires existing and proposed emission sources to demonstrate compliance with those standards. The applicable NAAQS for the seven criteria air pollutants are provided in **Table 3.1-1**, including the relevant time frame of the standards and calculation method. While some states adopt air quality standards that are more stringent than the NAAQS, the NGS is regulated by USEPA, so the federal statutes and regulations apply. USEPA has delegated the Clean Air Act's Title V operating permit program under 40 CFR Part 71 to the Navajo Nation Environmental Protection Agency.

Table 3.1-1 National Ambient Air Quality Standards

Pollutant	Standard	Averaging Time	Concentration		Statistical Form
			ppbv	μg/m³	
Nitrogen dioxide (NO_2)	Primary	1-hour	100	188	3-year average of the annual 98th percentile highest daily 1-hour concentrations
	Primary and Secondary	Annual	53	100	Annual mean
Sulfur dioxide (SO_2)	Primary	1-hour	75	196	3-year average of the annual 99th percentile highest daily 1-hour concentrations
	Secondary	3-hour	500	1,300	Annual second highest value
Carbon monoxide (CO)	Primary	1-hour	35,000	40,000	Annual second-highest value
	Primary	8-hour	9,000	10,000	Annual second-highest value
Particulate matter (PM_{10})	Primary and Secondary	24-hour	NA	150	Not to be exceeded more than 3 times over 3 years
Particulate matter ($PM_{2.5}$)	Primary and Secondary	24-hour	NA	35	3-year average of the annual 98th percentile highest daily average concentrations
	Primary	Annual	NA	12	3-year average annual mean value
	Secondary	Annual	NA	15	3-year average annual mean value
Ozone	Primary and Secondary	8-hour	70[1]	137[1]	3-year average of the annual fourth-highest daily 8-hour concentrations
Lead	Primary and Secondary	3-month rolling	NA	0.15	Not to be exceeded

[1] Revised October 2015.

PM_{10} = particulate matter with an aerodynamic diameter of 10 microns or less.

$PM_{2.5}$ = particulate matter with an aerodynamic diameter of 2.5 microns or less.

ppbv = parts per billion by volume.

μg/m³ = micrograms per cubic meter, based on standard conditions.

NA = Not Applicable.

Source: USEPA 2016. 40 Code of Federal Regulations (CFR) Part 50.

In ongoing review and regulatory actions, USEPA and the state and tribal governments designate areas as:

- "attainment," or "better than national ambient air quality standards" if monitored data demonstrate compliance with the standards;
- "unclassifiable" or "cannot be classified" if monitored data are not available for such determinations; or
- "non-attainment" (specifically: "Does not meet primary standards" or "Does not meet secondary standards") if monitored values of the criteria air pollutants are above the NAAQS.

Non-attainment areas for ozone also may be sub-classified from marginal to extreme" and non-attainment areas for PM_{10} and $PM_{2.5}$ may be sub-classified as moderate or serious depending on the air quality levels. In the 300-kilometer (km) area around NGS and the proposed KMC, all areas are designated as attainment or unclassified, therefore, the area is in compliance with the NAAQS. The air quality in the area around the transmission lines and communication sites would not be affected by the Proposed Action because only small and intermittent emissions are generated by the Proposed Action and action alternatives.

The NAAQS were established to provide ample protection of air quality, even for receptors that may be particularly sensitive to air quality conditions (also see Section 3.16) such as children, the elderly, and acutely or chronically ill persons with respiratory diseases. Sensitive receptor locations can include schools, day care facilities, hospitals, senior citizen centers, and recreational areas that are frequented by youth.

3.1.1.2 Hazardous Air Pollutants

Hazardous air pollutants (HAPs), as defined in Section 112(b) of the Clean Air Act, would be generated by some operations under the Proposed Action and action alternatives. **Table 3.1-2** provides selected regulated sources of HAPs that must comply with specific requirements as provided under the National Emission Standards for Hazardous Air Pollutants (40 CFR Part 63). There are numerous standards within this regulation that would not apply to the Proposed Action or alternative emission sources.

Table 3.1-2 Summary of Hazardous Air Pollutant Regulations

Regulation	Summary	How the Facility Complies
Hazardous Air Pollutants	Regulation of HAPs was expanded as part of Title III of the Clean Air Act in its 1990 amendments. The Clean Air Act identifies 186 chemicals or chemical groups as HAPs that may cause cancer or other serious effects on humans or adverse ecological effects. Diesel particulate matter and Diesel Exhaust Organic Gases also have been identified as carcinogenic HAPs (66 Federal Register 17235). There are no U.S. or Navajo National Environmental Protection Agency ambient air quality standards for HAPs, but emissions are controlled under various stationary and mobile source emissions standards. Some states have adopted separate sets of air quality levels for these and similar pollutants, but those standards do not apply to the Proposed Action. The Clean Air Act regulations include establishing national emission standards for HAPs for stationary sources under Title III of the Clean Air Act, with regulations promulgated in 40 CFR Parts 61 and 63. These regulations limit emission of HAPs from new and existing sources and apply to a wide range of specific source categories.	The implementing regulations in 40 CFR Part 63 include requirements for reciprocating internal combustion engines (Subpart ZZZZ). Two of the emergency generators at NGS are regulated under under Part 63.6590(b)(3)(iii) as existing emergency stationary reciprocating internal combustion engines, with a site rating of less than 500 brake horsepower, located at a major source of HAPs. Two auxiliary boilers also are regulated as existing oil-fired boilers under 40 CFR 63 Subpart DDDDD.
The Mercury and Air Toxics Standards Rule	The implementation of National Standards for HAPs includes a final regulation for HAP emissions from electric generating units (40 CFR 63 Subpart UUUUU), which applies to NGS. This regulation also is known as the Mercury and Air Toxics Standards Rule for power plants. It limits emissions of mercury acid gases, (hydrogen chloride or surrogate sulfur dioxide) and HAP metals (antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, nickel, and selenium) which may be regulated as individual metals emissions, total metals emission, or total particulate matter emissions.	NGS has implemented the monitoring, testing, recordkeeping, and reporting requirements, and performed the applicable work practice standards that are mandated to demonstrate compliance with the Mercury and Air Toxics Standards Rule.

Source: USEPA 2015c.

The ambient concentrations and deposition rates of selected HAPs are key components of the evaluations related to the Ecological Risk Assessments (ERAs) that are reviewed in Sections 3.8 through 3.13 for vegetation, terrestrial wildlife, and aquatic biological resources, as well as the Human Health Risk Assessments (HHRAs) reviewed in Section 3.16.

3.1.1.3 Regional Haze

In the 1977 Amendments to the Clean Air Act, Congress added Section 169A to establish a national goal of the "prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I Federal areas which impairment results from manmade air pollution." In 1980 USEPA promulgated regulations to address "reasonably attributable" visibility impairment in Class I national parks and wilderness due to a single source of small group of sources. Reasonably attributable visibility impairment has been certified for six coal-fired electric generating facilities since 1986. In March 1986 the Department of the Interior certified that Navajo Generating Station was causing visibility impairment in Grand Canyon National Park. After detailed technical analyses, public comment, and regulatory actions, emission controls to reduce sulfur dioxide were installed on the three NGS units between 1997 and 1999.

In the 1990 Amendments to the Clean Air Act, Congress added Section 169B to address regional haze, which is visibility impairment produced by multiple sources and activities across a broad geographic area. The Grand Canyon Visibility Transport Commission was created to recommend strategies to protect visual air quality at national parks and wilderness areas on the Colorado Plateau and made recommendations to USEPA in 1996.

In 1999 USEPA promulgated the Regional Haze Rule that requires states or tribes to submit implementation plans every ten years that demonstrate long-term emission reduction strategies to improve visibility in Class I national parks and wilderness areas. In 2013 USEPA implemented a federal plan for NGS to meet the regional haze rule requirements to reduce visibility impacts of nitrogen oxides (USEPA 2013).

3.1.2 Study Areas

3.1.2.1 Proposed Action and Action Alternatives

The air quality study area is driven by the near- and far-field analysis distances of the employed guideline models (40 CFR Part 51 Appendix W provides a detailed description of model guidelines and limits of analyses). NGS is the major, regulated source of air emissions associated with the Proposed Action as emissions from tall stacks are dispersed over a broad area (Ramboll Environ 2016a). Therefore, the study area generally encompasses a 300-km distance from NGS (**Figure 3.1-1**). This distance also is used to evaluate impacts on Class I areas under the federal Prevention of Significant Deterioration regulations in 40 CFR Part 52.21. The study area does not extend beyond this distance, although the transmission lines and communication sites are located outside this study area. The emissions from the transmission line and communication site operations (e.g., truck and maintenance equipment use) would be intermittent and below any threshold that would trigger a review under air quality permitting requirements. Therefore, the study area does not specifically include these portions of the Proposed Action or alternatives.

A subset of the study area was used to assess NGS Near-field air quality and impacts through the use of the guideline AERMOD model, which is considered appropriate for a distance of 50 km from the modeled sources. That area includes distances up to 50 km from NGS, as reflected in **Figure 3.1-1**.

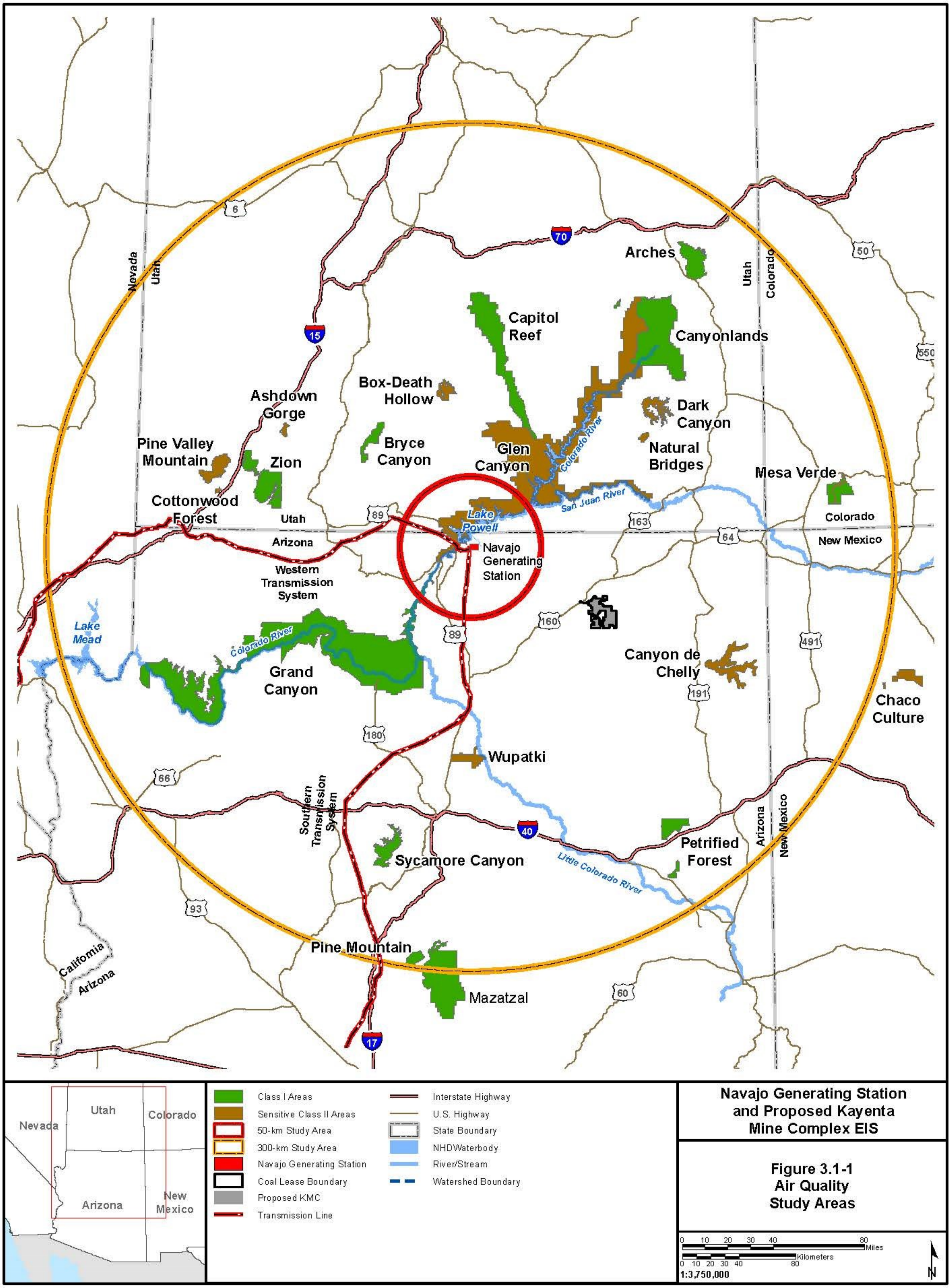

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Figure 3.1-1
Air Quality
Study Areas

A separate subset of the study area was used to assess air quality and impacts for the proposed KMC operations, which includes distances up to 50 km from the proposed KMC emission sources, as reflected in the dispersion modeling used to evaluate impacts associated with the proposed KMC mining activities (McVehil-Monnett Associates, Inc. [MMA] 2016).

3.1.2.2 Cumulative

The analysis of cumulative impacts within the study area also encompasses the broad 300-km study area and specifically includes the Class I and sensitive Class II areas within that area (**Figure 3.1-1**). The cumulative study area is the same as the study area for the Proposed Action. Given the nature of dispersion modeling and the necessity to have a large scale grid for photochemical modeling, some model results extend beyond that boundary; however, cumulative impacts were not evaluated beyond the 300-km distance.

3.1.3 Affected Environment

The affected environment analysis addresses the air quality emissions associated with existing facilities within the study area and the existing air quality conditions in the study area for NGS, the proposed KMC, and the transmission systems and communication sites.

3.1.3.1 Navajo Generating Station

NGS is located in a remote area, relatively distant from other major sources of air emissions. Although the impact from NGS emissions may reach to 300 km, impacts near the facility are dominated by NGS alone because there are no major sources (i.e., 100 tpy or more) within 50 km of NGS.

The USEPA develops a National Emissions Inventory for all listed sources in the U.S. every 3 years; the latest available set of such data is for 2011. **Table 3.1-3** lists data from the USEPA source inventory for 2011 for major sources (i.e., with emission of any pollutant above 100 tpy), for sources in southern Utah, northern Arizona, and the northwestern corner of New Mexico (San Juan County). **Figures 3.1-2a** through **3.1-2d** depict the location of these sources and the relative magnitude of the emission rates for oxides of nitrogen (NO_X), SO_2, PM_{10}, and $PM_{2.5}$, respectively. Representative names of these sources are included in the figures. Emissions impacts from other regional urban areas (Phoenix, Salt Lake City, Las Vegas) would be represented as background concentrations currently monitored at the regional air quality sites. The tabulated data are for 2011, and do not capture changes in air quality control since that time. NGS stands out as a relatively isolated emission source in these depictions.

3.1.3.1.1 Regional Air Quality

USEPA's Air Data Summary (USEPA 2014b) provides recent ambient air quality monitoring results at several sites in the region. The results are presented for sites in northern Arizona, Southern Utah, extreme northwestern New Mexico (San Juan County), and southwestern Colorado. There are no major industrial areas in the region; therefore, the ambient monitoring sites tend to be based in National Parks and in smaller local communities. The wide array of data from near Phoenix, Salt Lake City, and other distant and more populated areas is not representative of this region; therefore, it is not presented.

Table 3.1-4 provides a listing of the criteria pollutants, the regional monitoring site locations, and the applicable regulatory design value used to compare to the ambient standards. **Figure 3.1-3** depicts the locations of the sites referenced in **Table 3.1-4**. Criteria air pollutants SO_2, PM_{10}, and $PM_{2.5}$ were monitored near Page, Arizona. The data recorded near Page (Glen Canyon) were used for modeling near-field impacts to assess the environmental consequences of the proposed extension of NGS operations.

Table 3.1-3 Existing Major Sources and Pollutant Emissions in the Study Area

Facility	Pollutant Concentration (tpy)					Latitude	Longitude
	NO_X	SO_2	PM_{10}	$PM_{2.5}$	VOC		
Arizona Public Service Company - Cholla Power Plant	10,995	6,738	378	361	-	34.940	-110.300
Ash Grove Cement Company: Leamington Cement Plant	1,729	-	-	-	-	39.562	-112.196
Catalyst Paper (Snowflake) Inc.	2,184	2,896	133	110	-	34.504	-110.336
Chemical Lime Nelson Plant	1,103	1,995	300	-	-	35.518	-113.314
Coronado Generating Plant	9,017	7,352	768	594	-	34.578	-109.272
El Paso Natural Gas - Mojave Topock Compressor Station	118	-	-	-	-	34.727	-114.463
El Paso Natural Gas - Williams Compressor Station	915	-	-	-	-	35.311	-112.066
ETC Canyon Pipeline, LLC: San Arroyo Plant	192	-	-	-	-	39.398	-109.124
Four Corners Power Plant	38,729	11,822	3,117	1,859	15	36.689	-108.480
Genpak Corporation: Polystyrene Foam Production Facility	-	-	-	-	107	37.682	-113.100
Graymont Western Us Incorporated: Cricket Mountain Plant	1,065	-	225	121	-	38.939	-112.817
Intermountain Power Service Corporation: Intermountain Generation Station	25,296	4,937	1,703	1,398	-	39.504	-112.581
Lynndyl, Utah	194	-	-	-	-	39.518	-112.380
Navajo Generating Station	19,840	4,643	4,108	2,833	31	36.904	-111.389
Novo Biopower, LLC	212	-	-	-	-	34.504	-110.336
Pacificorp: Carbon Power Plant	3,665	7,740	633	532	-	39.727	-110.864
Pacificorp: Hunter Power Plant	13,720	4,662	595	349	117	39.173	-111.029
Pacificorp: Huntington Power Plant	6,192	2,531	428	121	-	39.379	-111.080
Patara Midstream, LLC: Lisbon Natural Gas Processing Plant	157	-	-	-	-	38.163	-109.276
Phoenix Cement – Clarkdale, Arizona	716	-	-	-	-	34.780	-112.084
San Juan Generating Station	17,104	4,741	496	438	192	36.802	-108.439
Sunnyside Cogeneration Associates: Sunnyside Cogeneration Facility	421	545	-	-	-	39.548	-110.383
Tucson Electric Power Company - Springerville	6,859	6,050	2,913	2,104	211	34.319	-109.164
Winslow, Arizona	256	-	-	-	-	35.029	-110.716

VOC = volatile organic compound.

Source: USEPA 2014a.

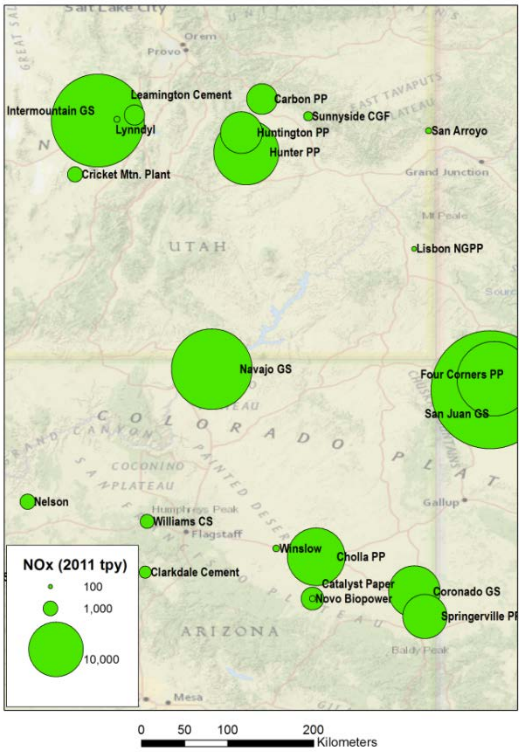


Figure 3.1-2a NO_X

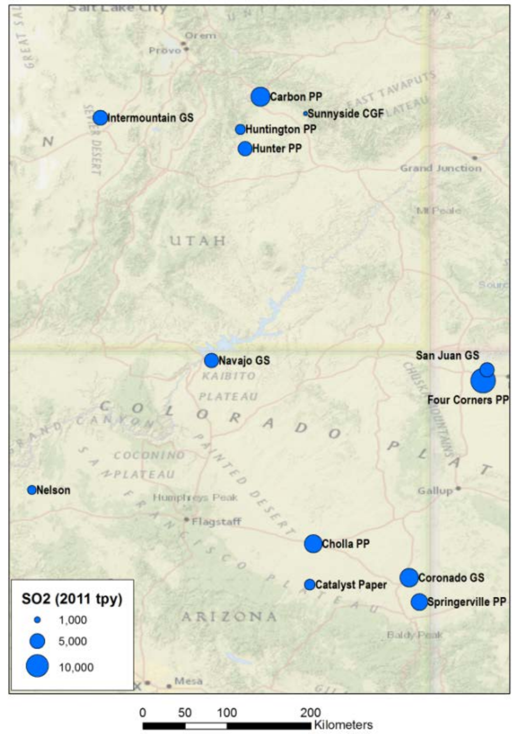


Figure 3.1-2b SO_2

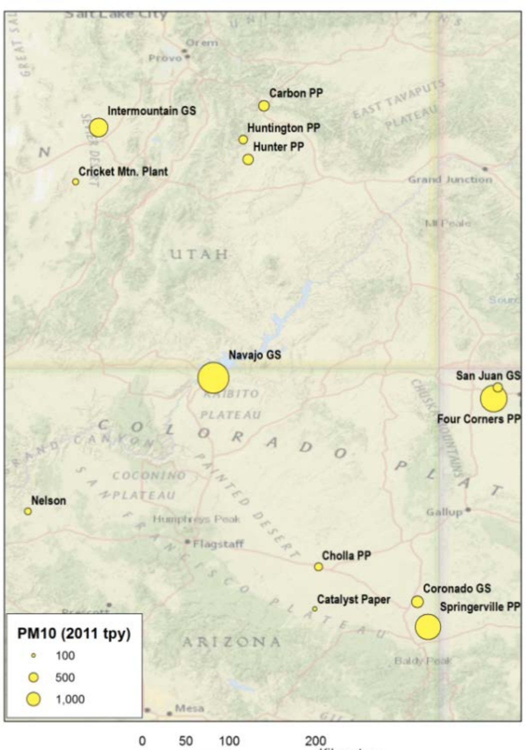
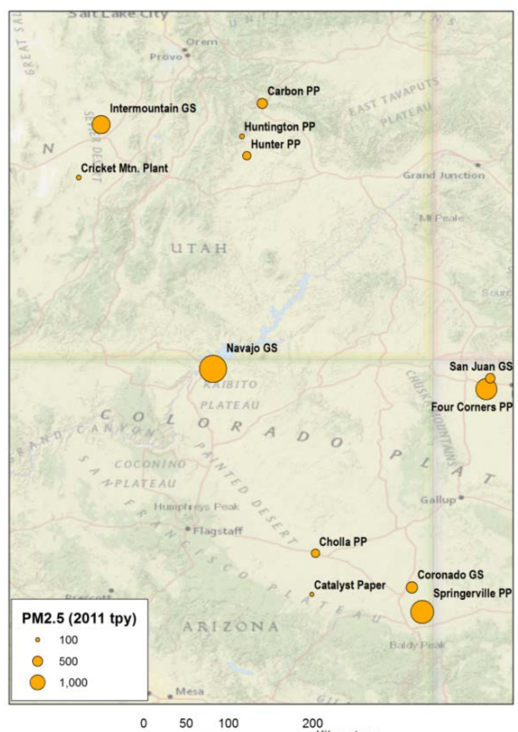


Figure 3.1-2c PM_{10}



Source: USEPA 2014a.

Figure 3.1-2d $PM_{2.5}$

Figure 3.1-2a-d Nearest Major Sources of Criteria Air Pollutants for NO_X, SO_2, PM_{10}, and $PM_{2.5}$

Table 3.1-4 Monitored Air Quality Conditions in the NGS-KMC Region

Pollutant	Site Location	2011	2012	2013 (3-yr avg)	2014 (3-yr avg)	Standard
NO_2 Annual Average (ppb)	Shiprock, NM	8.8	5.6	8.0	4.7	53 ppb
	Hurricane, UT [1]	9.3	9.2	10.1	9.4	
NO_2 8th Highest Hourly Daily Maximum (ppb)	Shiprock, NM	36	37	38	32	100 ppb (3-year average)
	Hurricane, UT	19 [2]	22	28	24	
CO 2nd Highest Hourly (ppm)	Ignacio, CO	1.3	0.8	1.7	1.3	35 ppm
CO 2nd Highest 8-hour (ppm)	Ignacio, CO	0.7	0.6	1.0	1.0	9 ppm
SO_2 99th Percentile Highest Hourly Daily Maximum (ppb)	Farmington, NM	20	24	25	14	75 ppb (3-year average)
	Bloomfield, NM	9	9	8	5	
	Page/Glen Canyon, AZ	9	10	7	8	
SO_2 2nd Highest 24-hour (ppb) [3]	Farmington, NM	3	4	3	2	140 ppb
	Bloomfield, NM	2	3	3	2	
PM_{10} 2nd Highest Daily (24-hour) Average ($\mu g/m^3$)	Flagstaff, AZ	37	35	27	--	150 $\mu g/m^3$
	Tuba City, AZ	48	50	--	--	
	McNary, AZ	59	56	54	48	
	Whiteriver, AZ	44	53	46	47	
	Page/Glen Canyon, AZ	15	23	49	33	
$PM_{2.5}$ 98th Percentile Highest Daily (24-hour) Average ($\mu g/m^3$)	Fort Defiance, AZ	12	10	--	--	35 $\mu g/m^3$ (3-year average)
	Flagstaff, AZ	14	12	10	--	
	Peach Springs, AZ	5	11	14	10	
	Zion NP/Hurricane, UT	12	12	12	9	
	Page/Glen Canyon, AZ	7	9	43	23	
	Farmington, NM	12	11	16	8	
$PM_{2.5}$ Annual Average ($\mu g/m^3$)	Fort Defiance, AZ	3.6	2.8	--		12 $\mu g/m^3$
	Flagstaff, AZ	5.2	5.4	5.4		
	Peach Springs, AZ	2.9	3.8	3.9	3.2	
	Zion National Park/Hurricane, UT	4.6	6.6	6.3	4.0	
	Page/Glen Canyon, AZ	2.1	3.2	11.5	6.2	
	Farmington, NM	4.1	4.9	5.0	3.7	
Ozone 4th Highest 8-hour Daily Maximum (ppb)	Flagstaff, AZ	68	72	69 (69)	73 (71)	70 ppb (3-year average) 75 ppb during 2011 to 2014
	Grand Canyon, AZ	74	73	69 (72)	69 (70)	
	Petrified Forest, AZ	69	73	69 (70)	68 (70)	
	Escalante National Monument, UT	-	68	67 (67)	60 (65)	
	Canyonlands National Park, UT	69	72	66 (69)	67 (68)	
	Hurricane, UT	68	59	69 (65)	70 (66)	
	Zion National Park, UT	72	75	70 (72)	69 (71)	
	Average	70.0	70.3	68.4	68.0	

[1] In Santa Clara Utah, near Hurricane

[2] Average for available monitored data in Washington County, Utah.

[3] Only 24-hour data reported for this site.

NP = National Park.

ppb = parts per billion.

ppm = parts per million.

$\mu g/m^3$ = micrograms per cubic meter.

Source: USEPA 2014b (for all air quality data except Page, Arizona).

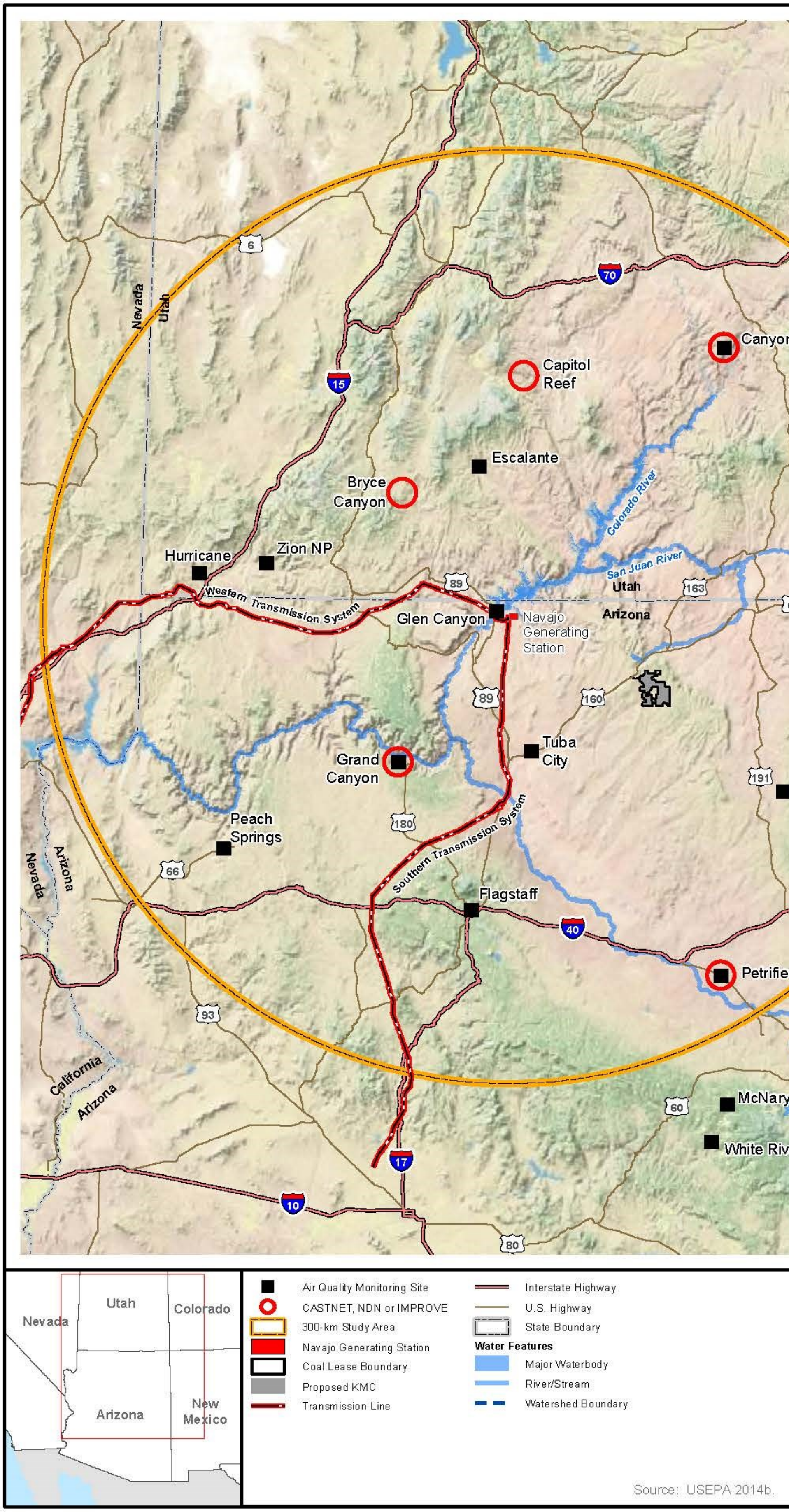


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Figure 3.1-3
Air Quality
Monitoring Sites

Representative data on SO_2 monitoring sites are limited; **Table 3.1-4** includes two locations in northwestern New Mexico as being the nearest sites. Data for carbon monoxide generally are collected in urban areas. For this analysis, the data recorded near Ignacio, a small community in La Plata County, Colorado, may be the most representative regional data. All monitored levels are well below the NAAQS.

Ozone data show considerable variability among the stations, with a general year-to-year consistency among the stations (e.g., 2012 was relatively higher and 2013 was relatively lower). Overall the seven station average of the annual 4th highest levels decreases from 70 ppb in 2011 to 68 ppb in 2014. Two data points could not be used to generate a statistical trend; however, the average levels point to a potential reduction in regional ozone levels. The 3-year averages for ozone provide a comparison to the 3-year design value concentration. The 8-hour ozone standard was 75 ppb during the 2011-2014 time period, but was revised to 70 ppb in October 2015 (80 Federal Register 65452).

Regional NO_2 data also show some year-to-year variability, but no clear trend in either the annual average levels or in the 8th highest of the annual daily 1-hour maximum levels. The data demonstrate that the regional air quality conditions are well below the NAAQS.

The PM_{10} data show 24-hour levels (2nd highest annual daily average) that are approximately 33 percent of the ambient standard. The $PM_{2.5}$ data also show interannual variability with no clear trend.

3.1.3.1.2 Visibility and Regional Haze

Visibility is a critical resource value in this region, particularly at the regional Class I areas (Colorado State University 2014a). Aerosols in the atmosphere scatter and absorb light. Multiple pollutant species contribute to total light extinction as measured at the IMPROVE monitors. Fossil fuel combustion is a major contributor to ammonium sulfate and ammonium nitrate aerosols, while wildland fires are major contributors to organic carbon and elemental carbon. These data represent a calculated value applied to the total atmospheric aerosol extinction (Colorado State University 1993) on a logarithmic scale that is intended to represent human perception of regional haze. Pristine conditions would be represented with a deciview value of zero. Deciview is a measurement of visibility impairment, and is a haze index calculated from light extinction. The deciview is expressed in terms of extinction coefficient (b_{ext}) and visual range (vr): haziness (dv) = 10 ln (b_{ext}/0.01 km-1) = 10 ln (391 km/vr). A change in deciviews of 1 would represent a small but noticeable change in haziness under most circumstances when viewing scenes in Class I areas (Colorado State University 1993).

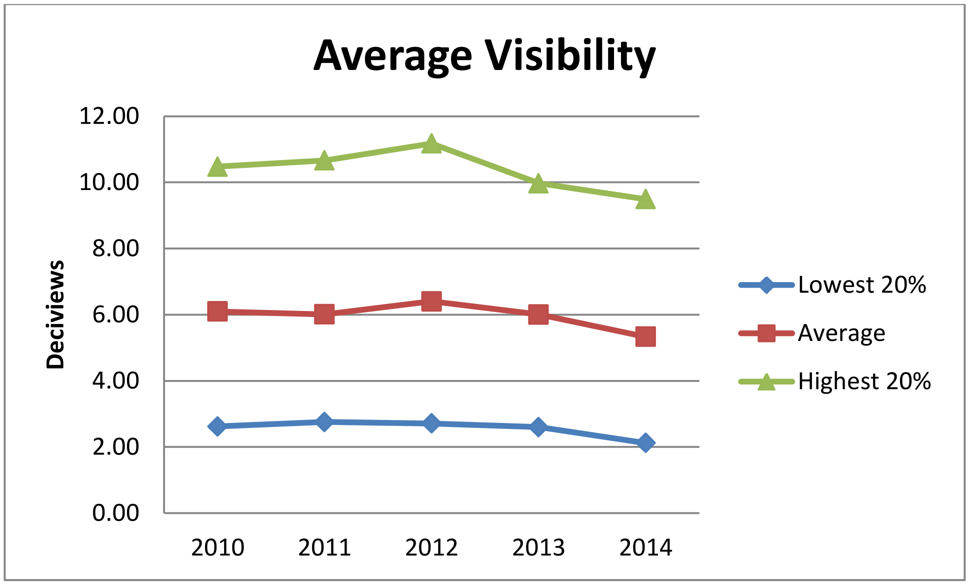
Table 3.1-5 depicts the average deciviews measured at the six indicated sites in the IMPROVE (Interagency Monitoring of Protected Visual Environments) Network. The IMPROVE program was initiated in 1985 to establish current visibility conditions and trends in National Parks and Wilderness Areas. **Table 3.1-5** provides data for the 20 percent least hazy (the lowest deciview levels) days, the average day, and the 20 percent haziest days (highest deciview levels) for the period from 2010 to 2013. These data were used to estimate a baseline regional haze level at the indicated sites through 2019.

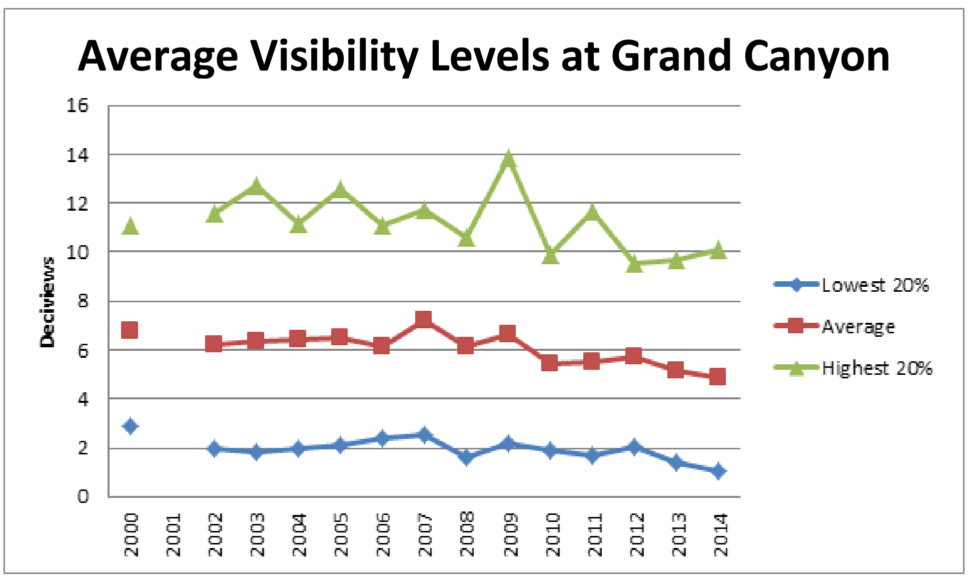
As with air quality conditions, there is notable variability in the data from year to year, but no clear trend at any of the sites or in any of the levels of haziness. The average of these three levels at the six sites are shown in **Figure 3.1-4** and indicate no clear trend; although, 2013 was slightly less hazy overall than the preceding 3 years. **Figure 3.1-4** also provides the haze levels at the Grand Canyon for 2000 through 2014 to provide a longer term perspective. The location of these Class I areas is depicted in **Figure 3.1-1**.

Table 3.1-5 Visibility (Haziness) Records at IMPROVE Sites

Parameter	Site	Visibility by Year (deciviews)				
		2010	2011	2012	2013	2014
Lowest 20% of Days (least hazy)	Bryce Canyon	1.66	2.00	1.67	1.40	1.16
	Canyonlands	2.74	2.74	3.20	3.37	2.60
	Capitol Reef	2.15	2.89	2.41	2.93	2.12
	Mesa Verde	3.03	3.18	2.73	2.91	2.44
	Grand Canyon	1.87	1.70	2.05	1.37	1.05
	Petrified Forest	4.27	4.03	4.24	3.63	3.37
Average of All Days	Bryce Canyon	5.55	5.28	5.80	5.51	4.89
	Canyonlands	5.78	5.73	6.27	6.32	5.37
	Capitol Reef	5.90	5.83	6.36	6.21	5.38
	Mesa Verde	6.41	6.25	6.42	6.32	5.14
	Grand Canyon	5.43	5.48	5.73	5.13	4.89
	Petrified Forest	7.51	7.51	7.84	6.55	6.36
Highest 20% of Days (haziest)	Bryce Canyon	9.39	10.77	10.46	9.16	8.49
	Canyonlands	10.70	9.91	11.61	10.40	9.14
	Capitol Reef	9.63	9.29	11.79	9.94	9.14
	Mesa Verde	11.78	10.47	11.57	10.58	9.52
	Grand Canyon	9.87	11.65	9.55	9.68	10.10
	Petrified Forest	11.49	11.90	12.10	10.07	10.56
Average	Lowest 20%	2.62	2.76	2.72	2.60	2.12
	Average	6.10	6.01	6.40	6.01	5.34
	Highest 20%	10.48	10.66	11.18	9.97	9.49

Source: Colorado State University 2016.





Source: CSU 2016.

Figure 3.1-4 Average Visibility Levels

3.1.3.1.3 Atmospheric Deposition

Natural ecosystems are affected by deposition of acidic compounds from the atmosphere to the soil, water, and living plant tissue. Acid deposition can have harmful effects on plants, aquatic animals, and infrastructure. Precursors include emissions of SO_2 and NO_X that can react with water molecules in the atmosphere to produce acids, which are deposited during rainfall events (i.e., wet deposition) or the settling of acid particles on the plant, waterbodies, and soil receptors (i.e., dry deposition). Existing data, including averages and annual trends in deposition, are provided for the monitored sites to depict the background setting. These data were used for comparison to the environmental consequences of the Proposed Action and action alternatives.

The Clean Air Status and Trends Network is a long-term environmental monitoring network throughout the U.S. and Canada designed to provide data to assess trends in air quality, atmospheric deposition, and ecological effects due to changes in air pollutant emissions. Data primarily are collected at National Parks, but other sites were added in 2012. The data are provided for 85 sites across the U.S., including four National Parks in the region of the Proposed Action (Canyonlands, Grand Canyon, Petrified Forest, and Mesa Verde). **Table 3.1-6** provides the overall average of dry deposition and wet deposition (collected from precipitation events) of nitrogen and sulfur compounds. Dry nitrogen deposition includes chemical species of nitrates and nitric acid, and dry deposition of sulfur includes chemical species of SO_2 and sulfates. The trend in deposition rates was calculated using a least-squares linear fit to the available data for 1990-2013. Individual yearly data for each site are provided in **Appendix 3.1-A**, **Tables 3.1-A.1** through **3.1-A.4**.

Table 3.1-6 Average and Trends in Atmospheric Deposition at Clean Air Status and Trends Network Sites (1990 to 2013)

	Average Deposition (kg/ha-year)				Trend (kg/ha-year per year)			
	Nitrogen		Sulfur		Nitrogen		Sulfur	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
National Park Sites	(NO_3)	(NO_3 + HNO_3)	(SO_4)	(SO_2 + SO_4)	(NO_3)	(NO_3 + HNO_3)	(SO_4)	(SO_2 + SO_4)
Canyonlands	1.16	0.89	0.60	0.22	-0.023	-0.023	-0.026	-0.008
Grand Canyon	1.21	0.82	0.60	0.21	0.015	-0.014	-0.008	-0.006
Petrified Forest	1.02	1.15	0.66	0.50	0.011	-0.050	-0.018	-0.041
Mesa Verde	1.46	0.97	1.07	0.28	-0.005	-0.014	-0.042	-0.014
Average	1.21	0.96	0.73	0.30	-0.001	-0.025	-0.024	-0.017

kg/ha = kilogram per hectare.

HNO_3 = nitric acid.

SO_2 = sulfur dioxide

SO_4 = sulfate.

NO_3 = nitrate.

Source: USEPA 2015a.

The National Deposition Network was formed by the U.S. State Agricultural Experiment Stations in 1977 and continually has added networks and stations since that time. The National Deposition Network collects data at 250 sites across the U.S. and represents a cooperative arrangement among federal, state, tribal, and local government agencies; educational institutions; private companies; and non-governmental organizations. In the NGS region, data have been collected at six sites used to depict the existing environment. These include the Grand Canyon National Park, Petrified Forest National Park, Mesa Verde National Park, Canyonlands National Park, Bryce Canyon National Park, and a site on Molas Pass, Colorado. Although data are collected by the Clean Air Status and Trends Network program in some similar locations, the results are affected by the representativeness of the particular site as well as the region. The National Deposition Network collects only wet deposition data. The annual average deposition rates of nitrogen compounds, sulfur compounds, and ammonia are provided in **Table 3.1-7** for the latest 5 years of data (2010 to 2014) (see **Appendix 3.1-B** for details). The shaded cells show the maximum deposition rate among the six sites for that year.

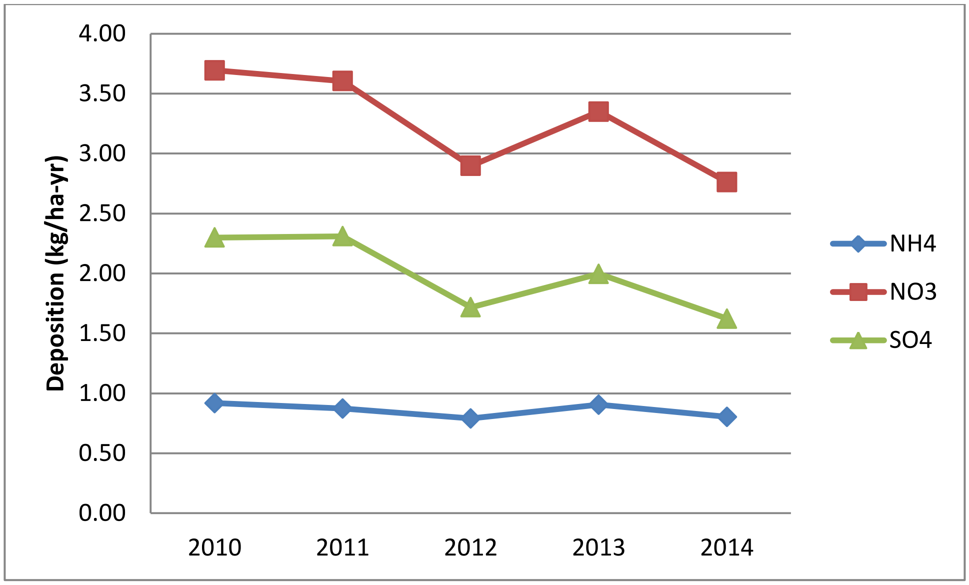
Table 3.1-7 Annual Average Deposition Rates At National Deposition Network Sites

Parameter	Site	Annual Average Deposition (kg/ha-year)				
		2010	2011	2012	2013	2014
Ammonium	Grand Canyon NP	1.91	0.7	0.9	0.92	0.69
	Petrified Forest NP	0.9	1.02	0.81	0.55	0.46
	Molas Pass, CO	0.68	0.9	0.99	0.92	1
	Mesa Verde NP	0.91	1	0.76	1.32	1.16
	Canyonlands NP	0.56	0.78	0.46	0.6	0.82
	Bryce Canyon NP	0.55	0.84	0.82	1.12	0.69
Nitrate	Grand Canyon NP	6.42	2.54	3.02	2.94	2.3
	Petrified Forest NP	2.65	3.7	2.48	1.64	1.24
	Molas Pass, CO	4.2	4.97	3.94	4.72	4.31
	Mesa Verde NP	4.5	4.89	3.5	5.27	4.39
	Canyonlands NP	2.45	2.5	1.62	1.95	2.13
	Bryce Canyon NP	1.94	3.03	2.82	3.58	2.2
Sulfate	Grand Canyon NP	3.58	1.54	1.32	1.38	0.97
	Petrified Forest NP	1.83	2.25	1.49	0.85	0.82
	Molas Pass, CO	1.97	2.53	1.84	2.46	2.23
	Mesa Verde NP	2.51	2.95	2.21	2.92	2.28
	Canyonlands NP	1.11	1.64	0.8	1.1	1.16
	Bryce Canyon NP	1.4	1.65	1.47	1.91	1.14
Averages	Ammonium	0.92	0.87	0.79	0.91	0.80
	Nitrate	3.69	3.61	2.90	3.35	2.76
	Sulfate	2.30	2.31	1.72	2.00	1.62

NP = National Park.

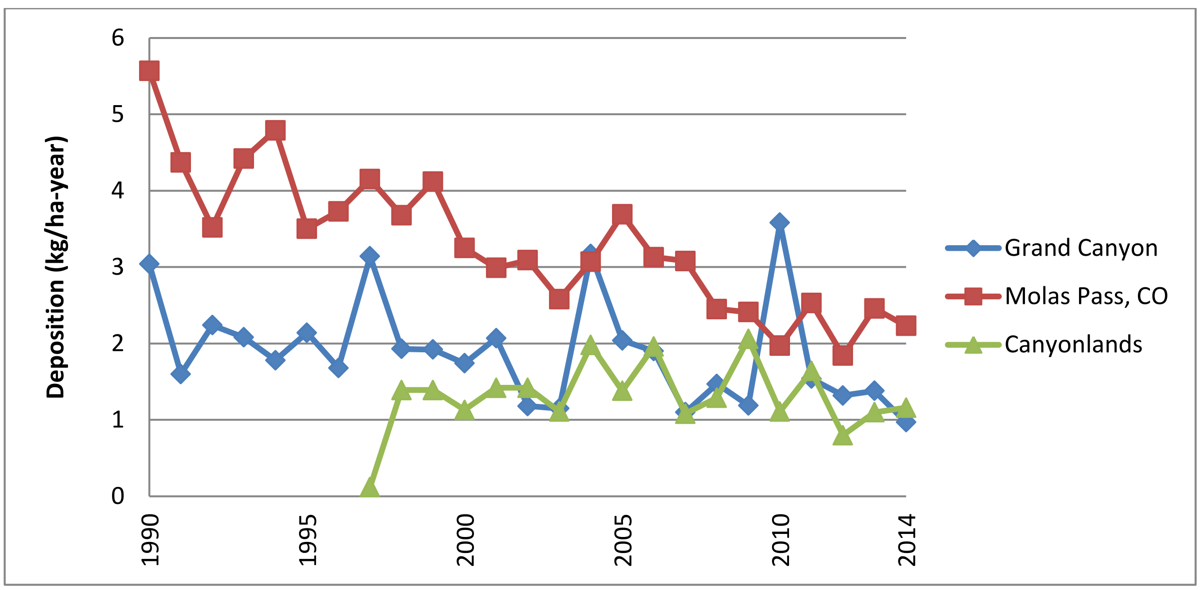
Source: National Atmospheric Deposition Program 2015a.

The National Deposition Network collects other deposition data as well, but those compounds are not relevant to the emissions from the Proposed Action. Ammonia levels are included because ammonia plays a role in enhancing the formation of sulfates and nitrates in the atmosphere, which ultimately are included in the condensable portion of $PM_{2.5}$. **Figure 3.1-5** provides the average deposition rate for ammonia, nitrates, and sulfates at the six sites noted above. It shows an overall reduction in these rates, particularly for nitrates and sulfates. Longer term data are available for three of those sites as shown in **Figure 3.1-6**. Wet sulfate deposition at Molas Pass, Colorado has shown a fairly consistent downward trend since 1990. The peak deposition at Grand Canyon National Park for 2010, which was seen in the Clean Air Status and Trends Network data, also is evident in this figure (see **Appendix 3.1-A** for details). The individual yearly peaks are part of the inter-annual variability in deposition that can occur at any one site in the region.



Source: USEPA 2015.

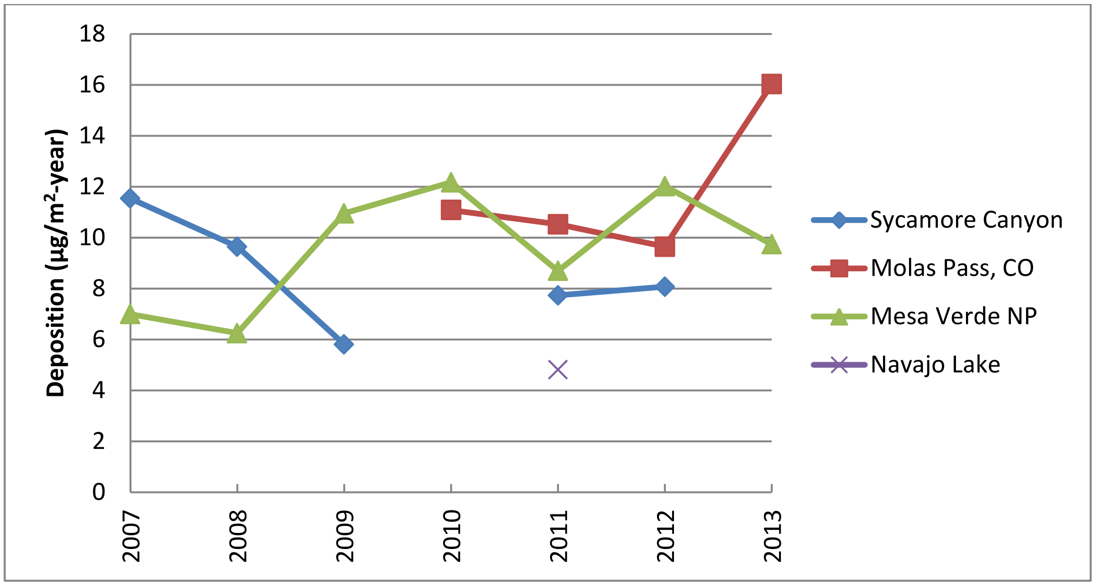
Figure 3.1-5 Average Total Annual Wet Deposition Rate at Six National Deposition Network Sites



Source: National Atmospheric Deposition Program 2015a.

Figure 3.1-6 Annual Wet Sulfate Deposition at Three National Deposition Network Sites

The National Deposition Network also started operating a Mercury Deposition Network in 1996 and currently collects data at over 100 sites in the U.S. and Canada. The collected data represent mercury deposition in precipitation events but not dry deposition. Available data for four sites in the region are provided in **Figure 3.1-7**. While the record is of a fairly short duration, the record for Mesa Verde extends from 2002 and provides the longest term continual representation of mercury (wet) deposition.



Source: Mercury Deposition Network 2015.

Figure 3.1-7 Annual Total Mercury Wet Deposition at Mercury Deposition Network Sites

Except for mercury deposition, the overall air quality conditions and air quality-related values in the region generally are improving or being maintained. Part of the improvement in these conditions may be attributed to improved emission controls on the region's power plants and on general improvements in emission from minor sources and motor vehicles.

3.1.3.2 Proposed Kayenta Mine Complex

The proposed KMC is within the 300-km study area. It is part of an active coal mine that has been in operation for 40 years. The Proposed Action incorporates land and facilities from the adjacent former Black Mea Mine without authorizing any further mining on those lands. Mining operations include extensive excavation and handling of overburden, excavation and handling of coal, and off-road mining equipment that generates emissions from fuel combustion and from fugitive dust. Air quality conditions are provided to depict the existing conditions at the residences located within the mine lease area boundary, as well as receptors that are on and beyond that boundary.

Peabody Western Coal Company collects ambient air quality data at the proposed KMC using monitors and samplers located on the mine lease area. The data show that ambient air quality conditions meet the NAAQS or the level of the standard (where less than 3 years' data have been collected, because compliance with some standards are based on 3 years of data). The data address conditions within the mine lease area because human residences occur within that area, and the monitoring is partially aimed at capturing the representative impacts on air quality for those residences. As a result, the proposed KMC data represent the critical air quality conditions in the affected environment in this study area. **Figure 3.1-8** depicts the identified resident receptors within and outside the proposed KMC permit boundary. The existing air quality conditions at the proposed KMC can be used to characterize the air quality at these receptor locations. Dispersion modeling was conducted that specifically addressed air quality impacts at those receptors. The available data are summarized in **Table 3.1-8**. SO_2 and CO are not monitored at this facility because there are no major sources of these pollutants. Carbon monoxide essentially is an urban pollutant related to high volumes of vehicular traffic.

Table 3.1-8 Monitored Air Quality Conditions at the Proposed KMC

Parameter	Site Location	2011	2012	2013	2014	Standard
NO_2 Annual Average (ppb)	N9[1,2] J21[3]		2.2	3.2 2.4		53 ppb
NO_2 8th Highest Hourly Daily Maximum (ppb)	N9 J21		39	36 35		100 ppb (3-year average)
PM_{10} 2nd Highest Daily 24-hour) Average[4] ($\mu g/m^3$)	AIRQ1 AIRQ2R AIRQ3R AIRQ4R AIRQ5R AIRQ6R AIRQ7R AIRQ8R AIRQ12 AIRQ200 AIRQ201 AIRQ202	31.1 42.4 66.0 41.5 49.9 32.9 40.5 67.2 52.7 33.7 47.2 32.6	55.8 62.3 109.7 39.5 37.7 34.1 26.1 55.2 67.8 28.2 47.2 53.5	36.7 53.1 80.8 83.8 80.4 37.7 34.8 56.1 97.1 32.2 72.0 54.4		150 $\mu g/m^3$
$PM_{2.5}$ 98th Percentile Highest Daily (24-hour) Average[5] ($\mu g/m^3$)	AIRQ1 AIRQ3R AIRQ6R				10 10 8	35 $\mu g/m^3$ (3-year average)
$PM_{2.5}$ Annual Average[5] ($\mu g/m^3$)	AIRQ1 AIRQ3R AIRQ6R				4.4 4.3 3.2	12 $\mu g/m^3$
Ozone 4th Highest 8-hour Daily Maximum (ppb)	N9[1,2]		70	66		75 ppb pre-2014, 70 ppb in 2014 (3-year average)

[1] Data collection began 08/01/2011.

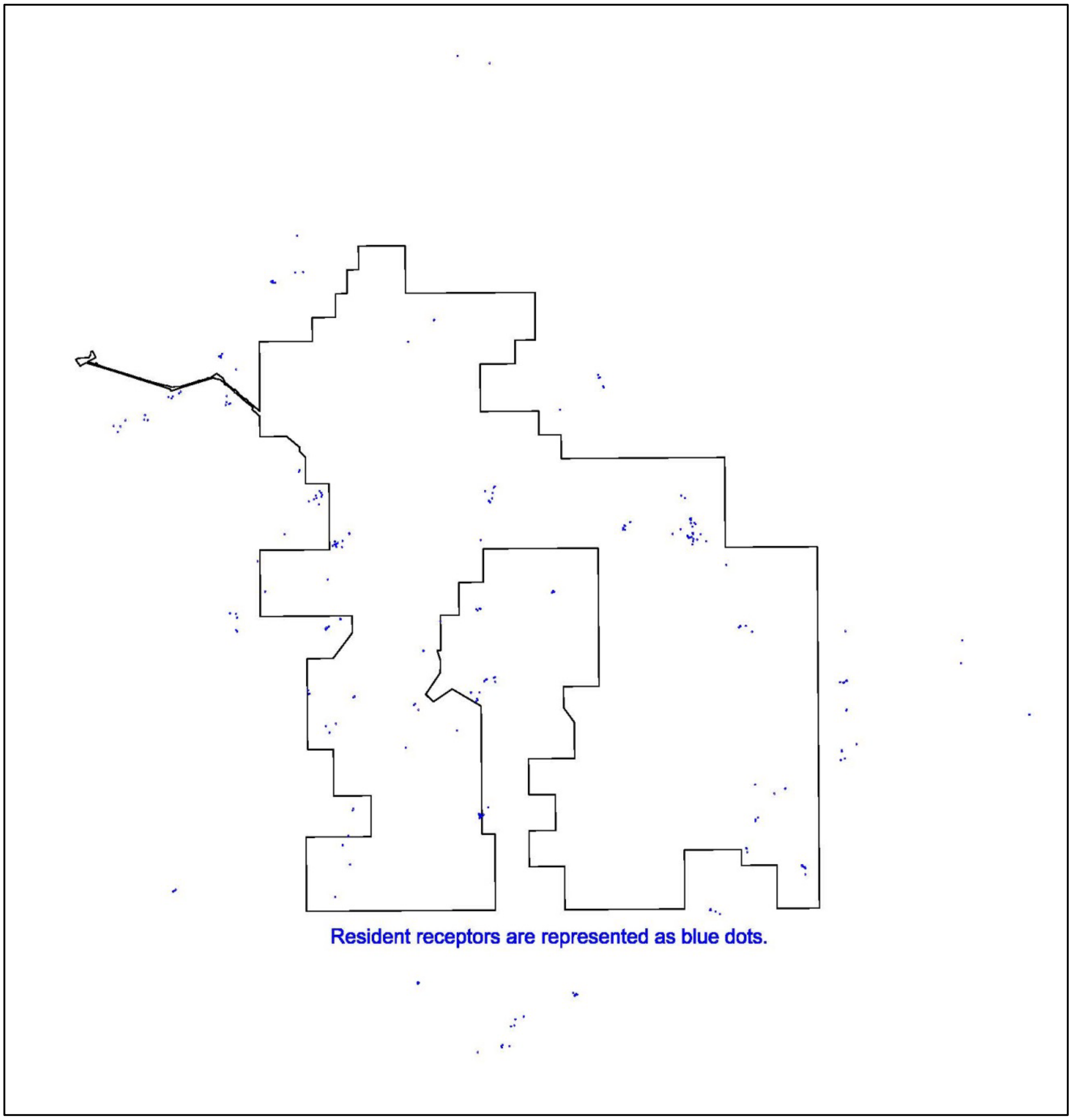
[2] Background data for 3-year monitoring period ended 07/31/2014.

[3] Valid data began on 02/01/2012.

[4] PM_{10} background 3-year monitoring period 01/01/2011 through 12/31/2013.

[5] $PM_{2.5}$ data collection began 10/01/2013.

Source: Lehn 2015.



Source: MMA 2016.

Figure 3.1-8 Residence Receptors at Proposed KMC

All ambient air quality data collected for this region, including the sites referenced above, indicate ambient levels well below the standards. A series of separate annual reports provides details of the data collection activities, monitoring results, and review of quality control and quality assurance activities for the monitoring program (**Appendix 3.1-C**).

3.1.3.3 Transmission Systems and Communication Sites

The existing transmission lines and communication sites operate at remote locations from NGS and the proposed KMC. The communication sites include propane-fired generators to provide backup emergency power. Many of the sites are operated and maintained by other users. Maintenance activities for the communication sites, transmission systems, and access roads can include vehicle traffic (vehicle exhaust and fugitive dust from unpaved roads), but the maintenance activities typically are infrequent, of short duration, and/or localized (**Appendix 1B**). For example, transmission line structure maintenance and repair occur on an as-needed basis; routine actions such as vegetation clearing occurs once every 5 years, or less frequently depending on need; repair of access roads and transmission tower infrastructure occurs along localized sections of the lines or roads as needed; and maintenance of access roads occurs once or twice a year, but equipment moves through the areas quickly.

3.1.4 Environmental Consequences

3.1.4.1 Issues

Air quality related issues center around demonstrating compliance with the existing, and applicable, NAAQS. In addition, data are provided for use in other resource reports related to climate change, deposition, human health, and ecological risk assessment. Specific air quality data and analyses characterized in capturing the environmental issues of the Proposed Action and action alternatives include in the following:

- Emissions from facility operations, considering equipment design, hours of operation, operational limits, control technologies, and any alternate scenarios. This task included identifying all relevant sources of emissions for each source, source grouping, or operation.
- Impacts on ambient air quality, determined through atmospheric dispersion modeling of the Proposed Action and action alternatives based on guideline technical analyses.
- Maximum impacts and spatial extent of impacts from the Proposed Action and action alternatives emissions compared to ambient air quality standards, including ozone levels.
- Extent of impacts from acid deposition and plume or visibility impacts at sensitive areas.

3.1.4.2 Assumptions and Impact Methodology

The estimation of environmental consequences requires analysis of air emissions, including emissions controls, and impacts on air quality conditions both locally and within the study area. The various emission assumptions and controls on operations at NGS are provided in **Table 3.1-9**.

Table 3.1-9 Key Assumptions Regarding Emissions Calculations at NGS

Operation or Source	Key Emissions Assumptions
Electric Generating Units Coal- and Oil-fired	Fuel feed rate, electrostatic precipitator and flue gas desulfurization Control Efficiency, Density of Fuel
Water Cooling Towers	Total dissolved solids, circulation rate, percent of solids not deposited on site, drift loss percent
Auxiliary Boilers	Fuel feed rate, density of fuel, approved factors for estimating emissions (e.g., USEPA AP-42)
Coal Handling and Storage (no coal pile)	Handling operations activity, approved factors for estimating emissions (e.g., USEPA AP-42), controls
Coal Storage Piles	Handling operations activity, USEPA AP-42 factors based on aggregate handling equation, controls
Limestone Handling and Storage	Limestone handling throughput, USEPA AP-42 factors, controls
Limestone Handling and Storage - Dust Collectors	Grain loading, average flow rate
Fly Ash Handling (no Disposal Site)	Fly ash bins, wetted bottom ash, transfers, baghouses
Fly Ash Handling - Disposal Site Materials Handling	Calculation of emissions at land fill, disposal and fugitive emission area
Soda Ash/Lime Handling	Handling operations activity, emission factors from USEPA AP-42 source-specific tables, or factors in USEPA AP-42 drop equation, controls
Fugitives - Mobile	Vehicle weights, controls, vehicle miles traveled, percentage onsite/offsite and paved/unpaved
Fugitives - Mobile - Coal Pile Bulldozing	Fuel use, hours of operation, Assumed equipment
Fugitives - Welding Rod	Rod usage and equivalent emission factor profiles from USEPA AP-42
Fugitives - Abrasive Blasting	Usage and USEPA AP-42 emission factors
Emergency Generators	Brake horse power, fuel feed rate, higher heating value and source of factors
Fuel Storage Tanks	Size, shape, throughput, vapor pressure, controls
Diesel Yard Switcher Locomotive	Tier, engine size, fuel consumption, hours of operation based on USEPA AP-42 conversion factors, sulfur content
Nonroad Equipment Exhaust on Roads	Horsepower, model year, hours of operation
Onroad Vehicles Exhaust on Roads	Vehicle size, model year, vehicle miles traveled
Nonroad Equipment at Landfills	Horsepower, model year, hours of operation
Onroad Vehicles at Landfills	Vehicle size, model year, vehicle miles traveled
Wind Erosion of Coal, Ash, and Limestone Piles	Pile size (area), moisture content, meteorological data, control effectiveness

Source: Ramboll Environ 2016d.

3.1.4.2.1 Impact Assessment – Modeling Approach

Impacts on ambient air quality near NGS were evaluated using a near-field air dispersion and deposition modeling analysis to estimate the potential local air quality impacts for receptors up to 50 km from NGS. The analysis focuses on comparing the modeled impacts with the NAAQS, considering both the emissions from NGS and from background sources.

The modeling analysis included air emissions of criteria air pollutants and HAPs associated with NGS. These emissions primarily occur due to the combustion involving coal in the electric generating units 1, 2, and 3 and the material handling equipment and operations of coal, lime, and ash. Smaller amounts of criteria pollutants and HAPs are emitted from the ancillary equipment such as vehicle exhaust, the auxiliary boilers, and other sources. The analysis includes criteria pollutants and HAP emissions associated with sources at the ash disposal site located 1 mile east of NGS.

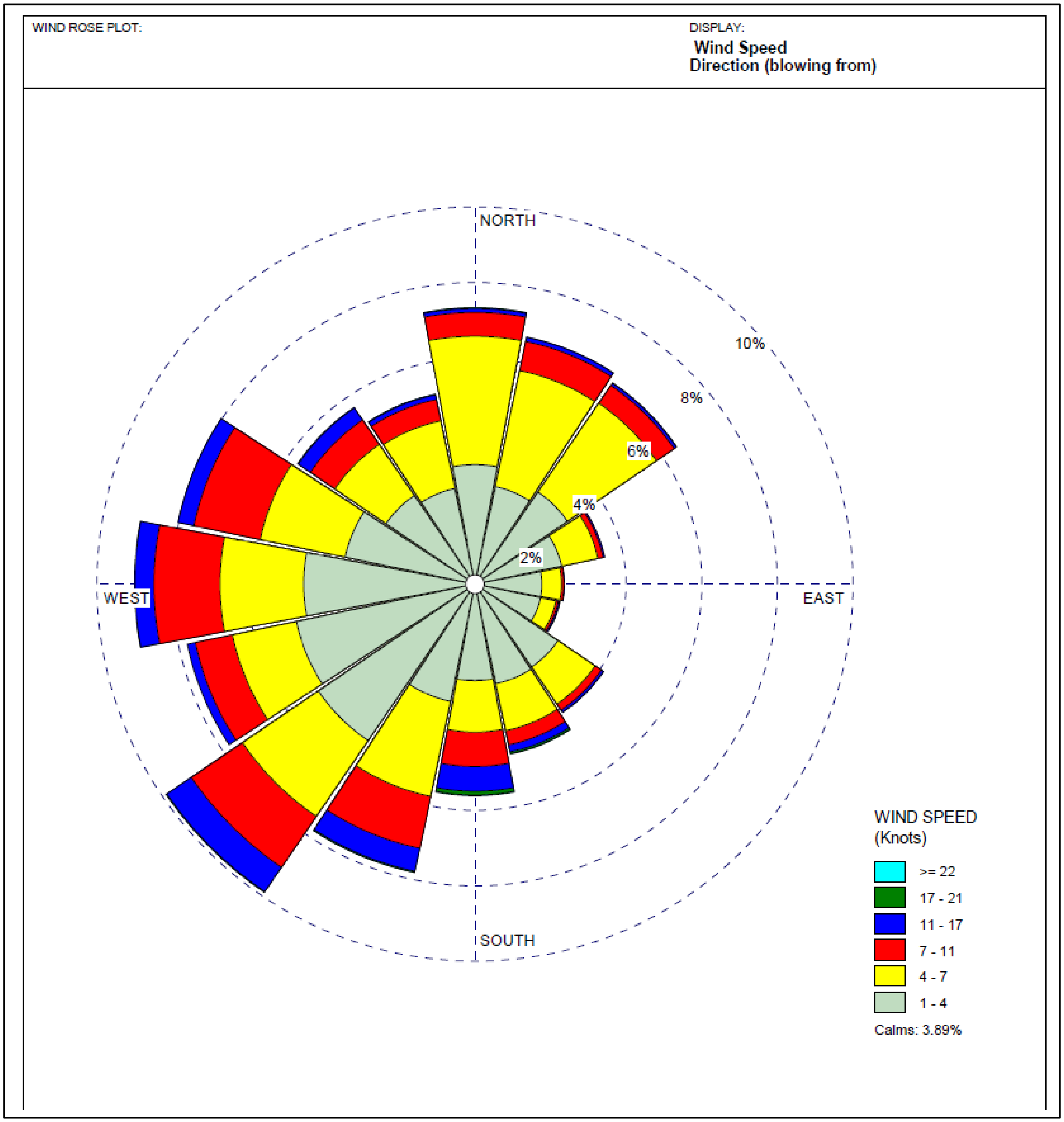
Modeling was conducted with AERMOD in accordance with the USEPA Guideline on Air Quality Models, as incorporated in Appendix W of 40 CFR Part 51. Version 14134 of AERMOD was applied. Environ (2015 [Section 3]) provides details of the modeling assumptions, setup, and input parameters. The model characterizes the emission sources as point, area, or volume configurations, depending on the nature of the emission source.

Impacts on visibility in Class I areas from NGS operation were taken from the USEPA Better than Best Available Retrofit Technology (BART) Alternative Federal Implementation Plan; therefore, impacts were not re-modeled in this analysis.

A 5-year meteorological database for 2008 through 2012 from the meteorological stations near NGS (i.e., Page Municipal Airport) was used for the dispersion and deposition modeling. This included the hourly precipitation data used in the simulations of wet deposition fluxes needed for the risk assessments as well as wind data, which influences the distribution of pollutant concentrations and hence dry and wet deposition.

A wind rose showing the wind speed and wind direction data collected at the Page Municipal Airport is provided in **Figure 3.1-9**. The wind rose indicates winds generally are from southwest and west. The average wind speed is approximately 2.4 meters per second, and winds are calm (i.e., wind speeds are less than 0.5 meters/second) for approximately 4 percent of the observations. This wind data provided the dispersion modeling input for AERMOD and depicts the influence of wind direction and wind speed on the impacts from surface level sources at NGS. As noted in the following discussion, the maximum impacts for criteria air pollutants are dominated by the low-level sources and surface operations at NGS. Impacts from the main boiler stacks also are influenced by the upper air pattern used in the AERMOD model.

For NGS existing (or background), air quality levels were taken from the Glen Canyon ambient air monitoring station, which is operated by NGS. This station is located 2.7 miles west of downtown Page, Arizona, and approximately 6 miles west-northwest of the NGS (**Figure 3.1-3**). The Glen Canyon monitoring site collects particulate matter ($PM_{2.5}$ and PM_{10}) and SO_2 ambient concentration data. Data for background ozone levels were taken from the Grand Canyon monitor, approximately 80 miles southwest of NGS. Hourly background NO_2 levels were taken from a combination of nearby monitors in Hurricane and St. George, Utah. For KMC, PM_{10} background concentrations were taken from Kayenta Mine on-site station AQ200, while NO_2 and ozone concentrations were taken from station N9. Off-site stations in Bloomfield, New Mexico; Farmington, New Mexico; and Ignacio, Colorado; provided background concentrations of SO_2, $PM_{2.5}$, and CO, respectively.



Source: Environ 2015.

Note: The concentric circles represent the annual frequency of the hourly wind direction from each of the 16 wind directions. The frequency of occurrence of each wind speed category is represented by the radial length of each speed category in each direction.

Figure 3.1-9 Wind Rose Plot for Page Municipal Airport

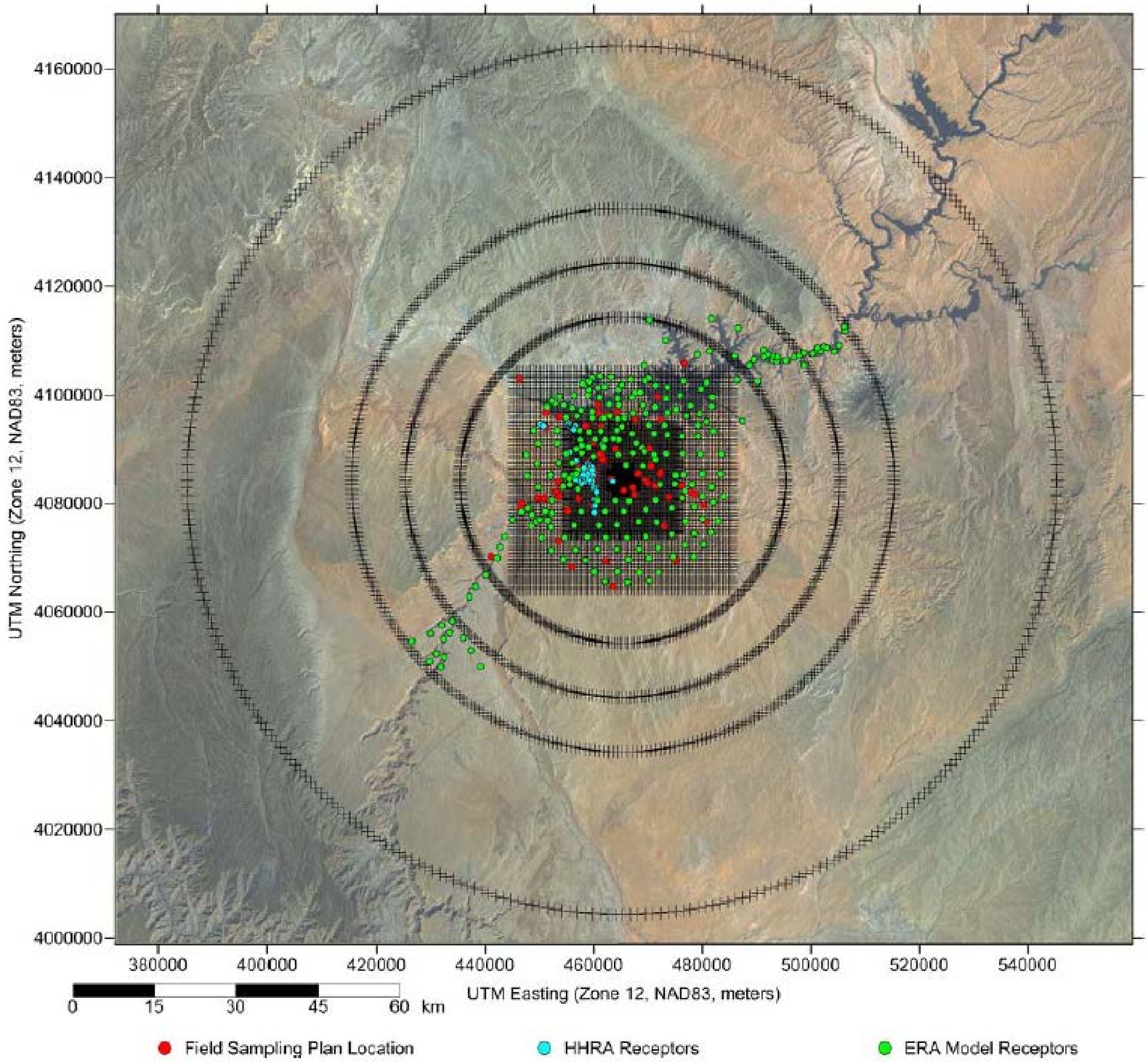
The impacts analyzed include ambient air quality conditions, regional visibility, and deposition of acidic compounds as well as hazardous or toxic air compounds. The impact analysis was based on both the expected short-term (24 hours or less) and long-term (annual) emission rate from all sources at NGS and the proposed KMC. Air quality impacts are compared to the No Action Alternative and NAAQS, and spatial depictions also are provided to evaluate the pattern of impacts. Emissions and impacts from the operation of the coal railcar delivery between the proposed KMC and NGS are negligible (Winges and Steffel 2016) and were not included in this analysis.

For both NGS and the proposed KMC, the USEPA regulatory guideline model AERMOD (the American Meteorological Society/Environmental Protection Agency Regulatory Model, Version 14134) was used to characterize the specific sources and to calculate impacts using locally applicable meteorological data (40 CFR Part 51, Appendix W). The guideline default parameters were used, with any exceptions explained in the proposed KMC Modeling Report (MMA 2016 [Section 5.0]) and the NGS AERMOD Modeling Protocol Report (Environ 2015 [Section 3.0]). This model was used to evaluate impacts at receptors within 50 km of the emissions source, and thereby serves as a local dispersion model for both NGS and the proposed KMC. The receptors used for NGS Near-field modeling is provided in **Figure 3.1-10**; residence receptors used for the proposed KMC Near-field modeling can be seen on **Figure 3.1-8** and the off-site receptors, including the permit boundary are shown in **Figure 3.1-11**.

The Kayenta Mine directly supports NGS and includes operations that generate air emissions. The AERMOD dispersion model (Version 14134) also was used in a separate analysis of impacts from mining operations, with the range of mining activity consistent with the 3-Unit Operation and 2-Unit Operation at NGS. The target production at the proposed KMC was 8.1 million tpy for the 3-Unit Operation and 5.5 million tpy of coal for the 2-Unit Operation. This model also analyzed ambient air quality impacts within 50 km of the emitting sources. Details of model setup and input preparation are provided in the proposed KMC Modeling Report Protocol (MMA 2016 [Section5.0]). The modeling effort included use of a wide range of emission factors associated with materials handling, excavation, and storage piles. The modeling also included assumptions about specific operating levels and hours of operation that are important for characterizing emissions and impacts. There are uncertainties regarding these assumed input values, but the modeling effort was based on accepted assumptions and on the details of the mine plan. Details of the assumptions are available in MMA (2016).

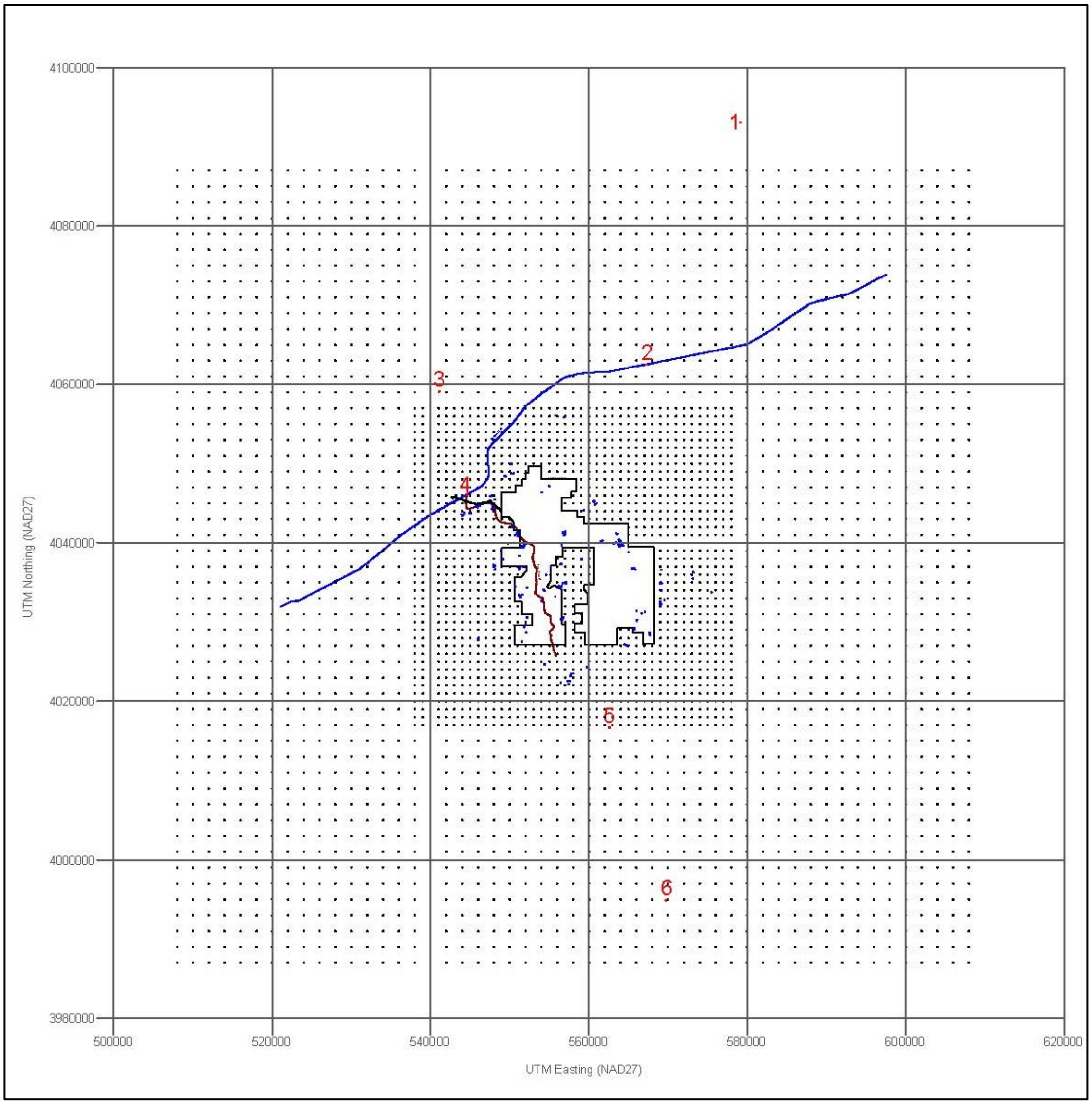
Five years of site-specific meteorological data from site BM-MET9 within the proposed KMC boundary were used for modeling, with concurrent data from the Flagstaff upper air soundings (or Albuquerque, New Mexico, as a backup).

The project is comprised of two major operations approximately 80 km apart; therefore, it was important to evaluate the additive effects of one component of the Proposed Action with the others. The proposed KMC operations mostly involve emission sources at or within 10 meters of ground level; therefore, any air quality impacts from proposed KMC that might overlap NGS would be negligible. However, given the height of the NGS stacks and the potential for long range dispersion, the impact of emissions from NGS that might overlap with the proposed KMC impacts is more likely to occur. To address that potential issue, the AERMOD model was used to determine the maximum impact from NGS emissions at any receptor at the proposed KMC as a means of characterizing that impact, and those deposition rates were used (i.e., added to the proposed KMC emissions) in the proposed KMC analysis. In addition, NGS emissions were included in background concentrations that were used in the NAAQS analysis for the proposed KMC.



Source: Ramboll Environ 2016b.

Figure 3.1-10 AERMOD Dispersion and Deposition Modeling Receptor Grid for NGS



Source: MMA 2016.

1 - Monument Valley Visitor Center
2 - Town of Kayenta
3 - Navajo National Monument
4 - Highway 160 and Navajo Route 41
5 - Forest Lake Chapter House
6 - Town of Piñon
Black dots are grid receptors; blue dots are residential receptors.

Figure 3.1-11 AERMOD Dispersion Modeling Receptor Grid for Proposed KMC

On a regional basis, the Comprehensive Air Quality Model with Extensions (CAMx) was used. CAMx includes an array of chemical and photochemical reactions that are important for the regional scale transformation of emissions in the atmosphere and was used in this environmental impact statement to evaluate NGS emissions for regional air quality impacts on ozone levels, visibility in Class II areas, and acid deposition in Class I and sensitive Class II areas.

3.1.4.2.2 Analysis Methods for Partial Federal Replacement Alternatives

Each of the Partial Federal Replacement (PFR) alternatives was evaluated based on the emissions and modeling results for the Proposed Action, using the data for the 3-Unit Operation and 2-Unit Operation. Those results were used to develop a scaling factor of emissions and impacts based on the operations and production levels for the Proposed Action at NGS and the proposed KMC. See Section 3.0 for a discussion of scaling factors. Analysis of each PFR alternative includes a reduced production level at NGS and the proposed KMC. The PFR alternatives do not include a specific limit on daily operations; therefore, the maximum daily emissions generally would not change. However, the modeled hourly and daily impacts for the 3-Unit Operation and 2-Unit Operation were used to develop a scaling factor for each of the PFRs, which was then used to estimate air quality impacts.

At NGS, the total annual average power production (in megawatts) was used to calculate a ratio for each PFR alternative to estimate the change in emissions and in modeled impacts. The maximum air quality impacts at NGS are dominated by surface level operations and occur near the ambient air quality boundary; therefore, there was very little difference in those impacts for each of the PFR alternatives except that SO_2 emissions and impacts are dominated by the three main stacks.

For the Natural Gas PFR Alternative, the natural gas replacement power would be provided by a natural gas combined cycle power plant, assumed to be similar to the facility that was permitted for the Bowie Power Plant in Arizona (Arizona Department of Environmental Quality 2014).

At the proposed KMC, the annual coal production levels for the 3-Unit Operation and 2-Unit Operation are used to develop the scaling factors for the corresponding operation of the PFR alternatives. The ratio of each of the PFR coal production alternatives to the Proposed Action coal production was then used to calculate the proposed KMC annual emissions and impacts.

3.1.4.3 Proposed Action

3.1.4.3.1 Navajo Generating Station

A range of NGS operating options included in the BART Federal Implementation Plan (79 Federal Register 46514-46555) limit air emissions to comply with the Regional Haze Rule. NO_X emissions would be reduced to achieve reasonable further progress for reducing human-induced regional haze in Class I areas. Under the Proposed Action, NGS would operate as either a 3-Unit Operation or 2-Unit Operation for the period 2020-2044. Future operational changes could include the installation of selective catalytic reduction (SCR) to reduce NO_X emissions under the 3-Unit Operation or 2-Unit Operation. The SCR control technology would be installed by 2030 for the 2-Unit Operation or by 2027 for the 3-Unit Operation. Emissions and impacts from NGS operations were assessed, including known control technology requirements. The 3-Unit Operation and 2-Unit Operation represent an upper and lower operational bound for the Proposed Action. As explained in Ramboll Environ (2016b [Section 2.4]), the range of operation to comply with the Regional Haze Rule was characterized by evaluating the lowest emitting scenario and the highest emitting scenario of the Proposed Action from an air quality perspective. If the facility were to operate at any of the other allowable emission rates within the BART Federal Implementation Plan, the air quality impacts would lie within these bounds. A detailed presentation of data used for this analysis is provided in **Appendix 3.1-D**.

This section includes a summary of emission rates and impacts for NGS. Details of the emissions data, control technology assumptions, modeling setup and configuration, and impacts are provided in Environ (2015) and Ramboll Environ (2016b,d) for NGS.

3.1.4.3.1.1 Emissions

Under the Proposed Action, the main emission sources from NGS are the stacks associated with the 3-Unit Operation or 2-Unit Operation of the individual boiler units that generate steam to produce electricity. Based on operational data and design information provided by NGS, each of the main stacks is 775 feet tall and were assumed for modeling purposes to be identical in terms of flue gas exhaust rate, temperature, and emissions of constituent gases. For each unit, emission controls include an electrostatic precipitator that controls particulate matter, a wet limestone slurry scrubber that controls SO_2, coal treatment with calcium bromide to control mercury, low-NO_X burner design to reduce NO_X emissions (both pre-and post-SCR installation), and the future installation of an SCR unit that would control NO_X emissions in the flue gas stream. Total mercury emissions, total particulate matter, and hydrogen chloride (SO_2 as a surrogate) must comply with allowable emission rates in the Mercury and Air Toxics Standards. Coal is treated with calcium bromide to ionize elemental mercury, and facilitate capture of mercury in the absorbers.

Emissions of hazardous air pollutants from the main stacks primarily are due to the presence of trace metals in the coal feedstock that also are listed as hazardous air pollutants under the Clean Air Act. The potential impact of these pollutants on the environment and human health are further addressed in the risk assessments. A total of seven selected trace metals were screened for deposition rates on soils and into water to determine those that required further evaluation in the risk assessments.

NGS is classified as a major source that generates carbon dioxide from combustion of the carbon in coal. NGS also emits methane and NO_X, which also are greenhouse gases formed in the combustion process. Although there are other listed greenhouse gases, these three compounds are the primary greenhouse gas constituents from the operation of NGS. The impacts of greenhouse gases are further discussed in Section 3.2, Climate Change.

The total annual emissions of criteria air pollutants and greenhouse gases are provided in **Table 3.1-10**. The table includes annual emissions associated with the period prior to 2020 and for both the 3-Unit Operation and the 2-Unit Operation of the Proposed Action for the years 2020 through 2044. The table also provides annual emission rates for the years both before and after the installation of SCR on the main boiler units for the 3-Unit Operation and 2-Unit Operation for those pollutants that are affected by the operation of the SCR.

Emissions of selected metals are critical to the ERAs and HHRAs. The total emission rates are provided in Ramboll Environ (2016d); however, the three metals critical to evaluation are mercury, arsenic and selenium. Total hourly emissions from the NGS main stacks for the 3-Unit Operation at 88 percent capacity (22,188 million British thermal unit per hour combined for 3 units) were used to calculate deposition and impacts to ecological resources and human health as follows:

- Mercury – 0.0266 pounds per hour
- Arsenic – 0.0306 pounds per hour
- Selenium – 0.511 pounds per hour

Detailed calculations for these and other HAP emissions are included in Ramboll Environ (2016a [Section 2.0]).

Table 3.1-10 Annual NGS Air Emissions from Electric Generating Units Main Boiler Stacks

Criteria Pollutants GHG and Target Metals	2019 Projections[1,2]	Proposed Action Pre-SCR[2] 3-Unit Operation (2020-2026)	Proposed Action Pre-SCR[2] 2-Unit Operation (2020-2029)	Proposed Action Post-SCR[2] 3-Unit Operation (2027-2044)	Proposed Action Post-SCR[2] 2-Unit Operation (2030-2044)
	(tons per year)				
SO_2	9,719	9,719	6,479	9,719	6,479
NO_X	20,409	20,409	13,606	6,803	4,535
CO	14,578	14,578	9,719	14,578	9,719
Total PM [3]	2,916	2,916	1,944	3,017	2,046
PM_{10} [3]	2,070	2,070	1,380	2,142	1,452
$PM_{2.5}$ [3]	1,487	1,487	991	1,559	1,064
H_2SO_4 mist	47.180	47.180	31.453	330.960	220.640
NH_4 (slip)	0.000	0.000	0.000	19.742	13.162
VOC	244.028	244.028	162.685	244.028	162.685
Arsenic	0.133	0.133	0.089	0.133	0.089
Lead	0.320	0.320	0.214	0.320	0.214
Mercury	0.117	0.117	0.078	0.117	0.078
Selenium	2.237	2.237	1.491	2.237	1.491
GHG (CO_2e)	20,088,469	18,108,000	12,072,000	18,108,000	12,072,000
	(pounds per hour)				
SO_2	2,219	2,219	1,479	2,219	1,479
NO_X	4,660	4,660	3,106	1,553	1,035
H_2SO_4 mist	11	11	7	76	50

[1] Represents 3-Unit Operation pre-SCR and is based on data provided by Salt River Project Agricultural Improvement and Power District (SRP) for option B2_A.

[2] Based on an annual capacity factor of 88 percent.

[3] Includes particulate sulfate and ammonium produced by NH_3 interaction.

GHG = greenhouse gas.

CO_2e = carbon dioxide equivalent.

H_2SO_4 = sulfuric acid.

lb/hour = pounds per hour.

NH_4 = ammonium.

Source: Ramboll Environ 2016d.

Emissions from support operations at NGS were included in the assessment of air quality impacts and ecological and human health risk assessments. Impacts from rail operations were not included because they have been determined to be negligible (Winges et al. 2016). These operations and emission rates are provided in **Table 3.1-11** for 3-Unit Operation and represent any year of the 3-Unit Operation from 2020 to 2044.

Table 3.1-11 NGS Emissions from Other Sources – 3-Unit Operation

Operation or Source	Emission Rate (tpy)						
	NO_X	SO_2	PM	PM_{10}	$PM_{2.5}$	CO	VOC
Electric generating units oil-fired	12.09	0.14	<0.01	<0.01	<0.01	2.52	0.10
Water cooling towers	-	-	19.22	0.86	0.02	-	-
Auxiliary boilers	0.48	0.14	0.04	0.02	0.00	0.10	0.00
Coal handling and storage (no coal pile)	-	-	0.61	0.21	0.03	-	-
Coal handling and storage - coal pile materials handling	-	-	1.81	0.63	0.10	-	-
Limestone handling and storage	-	-	0.09	0.09	0.01	-	-
Limestone handling and storage - dust collectors	-	-	1.47	1.47	0.40	-	-
Fly ash handling (no disposal site)	-	-	15.64	7.82	1.18	-	-
Fly ash handling - disposal site materials handling	-	-	0.68	0.24	0.04	-	-
Soda ash/lime handling	-	-	0.17	0.17	0.03	-	-
Fugitives - mobile	-	-	200.75	50.10	5.85	-	-
Fugitives - mobile - coal pile bulldozing			33.30	8.94	0.73		
Fugitives - welding rod	-	-	0.10	0.10	0.10	-	-
Fugitives - abrasive blasting	-	-	1.85	0.44	0.04	-	-
Emergency generators	8.47	0.56	0.65	0.60	0.60	1.83	0.68
Fuel storage tanks	-	-	-	-	-	-	1.77
Diesel yard switcher locomotive	0.13	0.00	0.00	0.00	0.00	0.23	0.01
Nonroad equipment exhaust on roads	35.18	0.31	2.25	2.07	2.01	14.95	3.29
Onroad vehicles exhaust on roads	1.04	0.00	0.06	0.05	0.04	3.32	0.18
Nonroad equipment at landfills	1.00	0.02	0.08	0.07	0.07	0.49	0.08
Onroad vehicles at landfills	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wind erosion of coal, ash, and limestone piles	-	-	134.16	28.17	4.23	-	-

Source: Ramboll Environ 2016d.

3.1.4.3.1.2 AERMOD Model Results

Results of the AERMOD modeling for NGS criteria air pollutants are provided in **Table 3.1-12** for the 3-Unit Operation and in **Table 3.1-13** for the 2-Unit Operation. The data represent the maximum impacts for either pre-SCR installation or post-SCR installation for the individual (3-Unit or 2-Unit) operations. The NO_2 impacts are conservatively based on the pre-SCR model results, as these emissions would be substantially reduced by the installation of SCR. The PM_{10} and $PM_{2.5}$ model results are conservatively based on the post-SCR model results, which include added ammonium, nitrate, and sulfate emissions from the operation of the SCR. The highest impacts tend to occur in the immediate vicinity of NGS for all criteria pollutants except SO_2, as noted in **Tables 3.1-12** and **3.1-13**. The near-field maximum model results for all pollutants except SO_2 are dominated by impacts from surface level sources that operate at the NGS facility, within 800 meters to 850 meters from the site boundary. Therefore, because the operations and emissions from the daily surface sources would not be affected by the 3-Unit Operation or 2-Unit Operation, there is little difference between the maximum1-hour or 24-hour impacts for NO_2, CO, PM_{10}, and $PM_{2.5}$ for the two operations. NO_X and PM_{10}/$PM_{2.5}$ impacts occur largely from heavy equipment exhaust and fugitive emissions at the plant site and not from the main boiler stack emissions. Impacts from SO_2 emissions are dominated by the main stack plumes, with peak maximum impacts occurring at approximately 8.3 km to the southeast of NGS.

The spatial depiction of maximum impacts also is relevant to evaluating the environmental consequences of the Proposed Action. The impact at the maximum receptor may be used for evaluation of compliance with the standards, but impacts at other receptors are notably less than the maximum receptor. Detailed spatial depictions of maximum impacts at other receptors are provided in Ramboll Environ (2016b [Section 5.0, Figures 5-1 through 5-33]) for all criteria air pollutants.

Table 3.1-12 Modeled Air Quality Impacts from AERMOD 3-Unit Operation

Pollutant	Primary or Secondary Standard (µg/m³)	Averaging Time	Concentration (µg/m³)			Location of Max Impact[2]	% of NAAQS
			Modeled Impact[1]	Background	Total Impact[1]		
NO_2	188	1-hour	186.4	—[3]	186.4	844.6, ESE	99
NO_2	100	Annual	14.4	6.0	20.4	807.8, ESE	20
CO	40,000	1-hour	746.5	3,664.0	4,410.5	850.6, ESE	11
CO	10,000	8-hour	154.6	2,633.5	2,788.1	822.8, ESE	28
SO_2	196	1-hour	141.1	22.5	163.6	8267, ESE	83
SO_2	1,310	3-hour	81.4	24.6	106.0	8375, SE	8
PM_{10}	150	24-hour	94.4	44.5	138.9	826.8, ESE	93
$PM_{2.5}$	35	24-hour	11.9	20.8 [4]	32.7	826.8, ESE	94
$PM_{2.5}$	12	Annual	1.8	5.9 [5]	7.6	807.8, ESE	64
Lead	0.15	Quarterly	0.0007	0.0100	0.0107	808.6, ESE	7

1 Maximum modeled impacts for NAAQS compliance based on the greater of the pre-SCR and post-SCR model-calculated results.

2 Simple direction and distance in meters from NGS middle stack.

3 NO_2 1-hour was modeled in AERMOD with seasonal, hourly background values (Ramboll Environ 2016b [Figure 4-2]).

4 $PM_{2.5}$ 24-hour background includes 1.0 µg/m³ secondary aerosol formation.

5 $PM_{2.5}$ annual background includes 0.26 µg/m³ secondary aerosol formation.

Source: Ramboll Environ 2016b.

Table 3.1-13 Modeled Air Quality Impacts from AERMOD 2-Unit Operation

Pollutant	Primary or Secondary Standard (μg/m^3)	Averaging Time	Concentration (μg/m^3)			Location of Max Impact[2]	% of NAAQS
			Modeled Impact[1]	Background	Total Impact[1]		
NO_2	188	1-hour	186.4	--[3]	186.4	844.6, ESE	99
NO_2	100	Annual	12.2	6.0	18.1	807.8, ESE	18
CO	40,000	1-hour	746.5	3,664.0	4,410.5	850.6, ESE	11
CO	10,000	8-hour	154.6	2,633.5	2,788.1	822.8, ESE	28
SO_2	196	1-hour	95.3	22.5	117.9	8267, ESE	60
SO_2	1,310	3-hour	54.1	24.6	78.7	8375, SE	6
PM_{10}	150	24-hour	93.2	44.5	137.7	826.8, ESE	92
$PM_{2.5}$	35	24-hour	11.8	20.8[4]	32.6	826.8, ESE	93
$PM_{2.5}$	12	Annual	1.6	5.9[5]	7.4	807.8, ESE	62
Lead	0.15	Quarterly	0.0006	0.0100	0.0106	808.6, ESE	7

[1] Maximum modeled impacts for NAAQS compliance based on the greater of the pre-SCR and post-SCR model-calculated results.

[2] Simple direction and distance in meters from NGS middle stack.

[3] NO_2 1-hour was modeled in AERMOD with seasonal, hourly background values (Ramboll Environ 2016b [Figure 4-2]).

[4] $PM_{2.5}$ 24-hour background includes 1.0 μg/m^3 secondary aerosol formation.

[5] $PM_{2.5}$ annual background includes 0.26 μg/m^3 secondary aerosol formation.

Source: Ramboll Environ 2016b.

The identification of the highest impacts nearest to the ambient standards for the NGS 3-Unit Operation can be extracted from the tables. The maximum predicted 1-hour NO_2 impact at an individual receptor would occur at the NGS boundary, at a level that is just below the ambient air quality standard. The 1-hour NO_2 impacts rapidly decline with distance from NGS. The 1-hour NO_2 impacts would be less than half the standard (approximately the 100 μg/m^3 contour line) beyond approximately 2.5 km (1.6 miles) in any direction from NGS (Ramboll Environ 2016b [Figure 5-2]).

Tables 3.1-12 and **3.1-13** also indicate that the background levels of $PM_{2.5}$ tend to dominate the impacts, and those background levels are below (approximately half) the ambient standard. Maximum impacts from NGS on ambient concentrations of $PM_{2.5}$ also are confined to receptors very near the NGS boundary. The 24-hour maximum $PM_{2.5}$ impact would occur at the NGS boundary, and the impacts rapidly decline with distance from NGS. Within 1 km from the NGS boundary, the maximum impact would be reduced from 32.7 μg/m^3 to approximately 24 μg/m^3, and impacts in all other directions would be well below the ambient standard.

It is important to emphasize that the maximum hourly impacts on NO_2 levels at NGS for all operations would not be affected by the installation of SCR in either operation or by the implementation of the 3-Unit Operation or 2-Unit Operation. These maximum impacts are dominated by the surface level NO_X emissions from ground operations, such as vehicle emissions and emissions from fuel burning equipment associated with coal handling. The maximum impacts would occur near the NGS ambient air boundary. Hourly operations of these units, and thereby maximum hourly NO_X emissions, would be unchanged for the pre- and post-SCR period and by the selection of the 3-Unit Operation or 2-Unit Operation. Ambient NO_2 concentrations at more distant receptors affected mainly by NO_2 emissions from the stacks would be reduced for the 2-Unit Operation and following SCR installation for both the 3-Unit Operation and 2-Unit Operation.

Fundamentally the analysis demonstrates that the Proposed Action, including options, would comply with the NAAQS for the criteria air pollutants (NO_2, CO, SO_2, PM_{10}, and $PM_{2.5}$). As shown in the figures in Ramboll Environ (2016b [Section 5.0]), the maximum impacts would occur very near the NGS ambient air boundary, and those impacts would decrease substantially with distance from that boundary. The results are a conservative estimate of actual impacts because conservative technical approaches provide results that likely over-estimate impacts.

Ambient air quality impacts from NGS operations would be moderate because the air quality effects would be readily apparent and would result in measurable impacts to the resource. However, all criteria pollutant impacts would be in compliance with NAAQS. Except for SO_2, the impacts would be dominated by ground-level operations, close to the ambient standards near the facility ambient air boundary, and decrease with distance to less than half of the ambient standards beyond 10 km from the facility. SO_2 impacts also would be in compliance with the standards, but the peak impacts would be limited to a very small area of high terrain to the southeast of NGS.

3.1.4.3.1.3 Air Quality and Deposition Impacts of Selected Metals

Trace metals are emitted from NGS operations including the fuel burned from surface equipment and vehicle operations, the metals in the coal that are emitted from the main stack, and the metals in coal and ash that are emitted from fugitive sources on site. The dispersion, ambient air quality levels, and deposition of these metals were evaluated to determine potential impacts from the Proposed Action and action alternatives on local biological receptors and human populations. The emission, dispersion, and deposition of those metals are analyzed in this section and used for input to the ERAs and HHRAs.

As noted above, the AERMOD model was used to determine air quality concentrations and deposition rates for HAP metals emitted from NGS, including both the main stack and process/handling emissions. **Table 3.1-14** provides the maximum impact at any receptor within 50 km from NGS for both ambient air quality impacts and deposition rates associated with the 3-Unit Operation. A spatial analysis of impacts (Ramboll Environ 2016b [Figures 5-35 and 5-36]) depicts the rate of change with distance from NGS, with these maximum values located at or near the NGS ambient air boundary. The impacts would decrease rapidly with distance from the NGS boundary.

Table 3.1-14 Maximum Impact and Deposition of HAP Metals from NGS Emissions

Pollutant	Averaging Period	Maximum Air Impact ($\mu g/m^3$)	Maximum Deposition (kg/hectare-year)
Arsenic	Annual	0.0000373	0.00088
Lead	Annual	0.000287	0.00303
Mercury	Annual	0.00000274	0.0000126
Selenium	Annual	0.000604	0.00655

Source: Ramboll Environ 2016b.

3.1.4.3.1.4 Air Quality Impacts at Class I Areas

The USEPA issued a Federal Implementation Plan to address regional haze impacts from NGS emissions on Class I areas within the study area under the Regional Haze Rule (40 CFR Part 49.5513). The Federal Implementation Plan addressed requirements for installation of BART on NGS to improve visibility in 11 Class I areas, and required the NGS operator to achieve NO_X emissions reductions to comply with the 2009-2044 NO_X emissions cap. The final action implemented the better than BART alternative that was consistent with an agreement developed by a joint Technical Working Group. SCR would be installed on units to comply with an emissions cap for NO_X for the period 2020-2029. USEPA's analysis of impacts at the 11 Class I areas is provided in the Federal Register (78 Federal Register 8286) for the original BART analysis. As shown in **Table 3.1-15**, the results showed improvement in visibility in the 98th percentile at all 11 Class I areas (from 2003 data). See the Federal Register publication (79 Federal Register (153) 46514-46555) for additional details on the Final Rule.

Table 3.1-15 USEPA Modeling Results

Class I Area	Distance to NGS (km)	Baseline Impact[1] (dV)	Improvement[1,2]	
			(dV)	Percent
Arches National Park	245	4.5	3.5	77
Bryce Canyon National Park	96	4.9	3.6	74
Canyonlands National Park	173	6.0	4.6	76
Capitol Reef National Park	90	7.7	5.4	71
Grand Canyon National Park	29	8.4	5.4	64
Mazatzal Wilderness Area	279	1.5	1.1	75
Mesa Verde National Park	253	3.2	2.6	81
Petrified Forest National Park	235	3.4	2.7	78
Pine Mountain Wilderness Area	287	1.3	1.0	75
Sycamore Canyon Wilderness Area	204	2.4	1.8	75
Zion National Park	134	4.4	3.3	76

1 From 98th percentile delta deciviews.

2 Improvement from SCR plus low-NO_X burners and supplemental over fire air for NO_X controls.

Source: CSU 2016; 78 Federal Register 8287.

Improvement is based on reduced impacts after 2018, but as discussed in the Federal Implementation Plan, the USEPA allows credit for reduced NO_X emissions from 2009 through 2019 and established a NO_X emission limit of 0.07 pounds/million British thermal unit. Therefore, the improvement with the better than BART alternative could be less than originally described for the individual years, but the better than BART alternatives would provide overall reduced impacts for the extended time period. The visibility impact analysis for the 0.07 pounds/million British thermal unit NO_X emission rate was not specifically analyzed.

The impacts of NGS on Class I areas would be moderate because impacts were calculated to remain above 1.0 deciviews; however, these impacts would be mitigated by 60 to 80 percent by the installation of SCR on the 3-Unit Operation by 2026 or on the 2-Unit Operation by 2030.

NGS has not been required to obtain a permit under the Prevention of Significant Deterioration regulations; therefore, they are not increment consuming facilities. As a result, their impacts on ambient air quality in Class I areas were not evaluated for comparison to those Class I increments. The existing ambient air quality conditions at those locations already reflect the impacts from historic and ongoing operations at NGS.

3.1.4.3.1.5 Plume Blight from NGS Emissions

Plume blight is defined as visual impairment of air quality that manifests itself as a coherent plume. This results from specific sources, such as a power plant smoke stack, emitting pollutants into a stable atmosphere. The pollutants are then transported in some direction with little or no vertical mixing. (Malm, 1999). Under stable meteorological conditions and current emissions, a viewer facing the Navajo Generating Station plume from vantage points within 50 km of NGS may see a discreet plume for some distance from the stack. Features of the plume will vary as a function of meteorological conditions and viewer position and distance from the facility.

3.1.4.3.1.6 Regional Haze at Nearby Areas

The impact of NGS at the Class II areas within 300 km of NGS also is reflected in existing air quality and haze conditions at those locations. A separate haze analysis is not mandated by federal or other agency requirements for these Class II areas in which visibility has not been identified as an important environmental resource, and was not conducted.

3.1.4.3.1.7 Indirect Effects from NGS

Indirect air quality effects from the Proposed Action largely would include the continued delivery of materials and chemicals to NGS, as well as hauling of coal combustion residuals off site to customers or to a separate landfill. During the Proposed Action period (2020-2044), NGS would continue to receive chemicals and support products. During the course of the Proposed Action, NGS also would begin receiving anhydrous ammonia or urea for use in the SCR system. The additional air quality effects from the added truck traffic are limited to the extra deliveries of ammonia. The impacts from truck traffic from existing operations would continue, or could be reduced under the 2-Unit Operation. On an annual basis, delivery of most chemicals and other feedstocks would be proportional to the expected power generation at NGS. With reduced power production for the 2-Unit Operation, the annual level of deliveries of materials and overall truck traffic would be reduced roughly comparable to the related reduction in power production.

The effect of indirect activities in support of NGS would be minor because the air quality effects of materials delivery would involve traffic on public highways, and emissions would have transient impacts at any specific location. The effect of traffic emissions (not specific to NGS indirect activities) was included in the photochemical grid modeling that was conducted for cumulative effects.

Under the Proposed Action 2-Unit operation, one of the electric generating units would be decommissioned along with any structures related specifically to that unit. At that time, any planning for salvage, sale, repurposing, abandonment in place, or demolition would be reviewed. It also is possible that under this operation, no demolition would occur until the facility as a whole is decommissioned. Except for demolition, there would be no or negligible air quality emissions. However, because the remainder of the facility would be operating under the Proposed Action, demolition activities would be limited in area and likely very brief. A quantitative assessment of those emissions or impacts is not possible with available data, but the air quality impacts likely would be negligible, particularly in relation to all other ongoing activities that support the 2-Unit Operation.

Additionally, under the Proposed Action, the entire NGS facility would be decommissioned at the end of the lease period (2044) unless the Navajo Nation elects to operate the station beyond 2044. If NGS is decommissioned, the lease requires that the land be restored as closely as possible to the original condition, requiring extensive demolition of most of the existing structures and facilities. Following any asbestos abatement, the remaining structures and equipment that were not recycled or salvaged would be dismantled and demolished, and all fuel, chemicals, waste, coal and other materials would be removed for disposal. Demolished inert materials would be buried in an on-site area, and covered by a stabilized surface with natural features in place above the disposal and abandonment area. From an air quality perspective, emissions would involve fugitive dust from demolition activities, soil handling, coal removal, and disposal and remediation activities. There also would be engine exhaust emissions from heavy equipment operations during demolition and surface activities. Given the nature of surface emissions at NGS for normal operations, including fugitive particulate matter and equipment exhaust, impacts within a few kilometers of the facility likely would be similar to those of normal operation. Impacts would be moderate at times during major activities of relatively short duration (i.e., approximately 1 year).

3.1.4.3.2 Proposed Kayenta Mine Complex

3.1.4.3.2.1 Emissions from Proposed KMC

Proposed KMC operations include a wide array of sources related to coal mining, handling and processing. Emissions of criteria pollutants are generated by mining operations (coal and overburden removal and transport), coal preparation plant activities (coal transfers, crushing, screening, stockpiling) and wind erosion of stockpiles and disturbed areas. The majority of these emissions consist of fugitive and process particulate matter (total suspended particulates, PM_{10}, and $PM_{2.5}$). Other pollutants (NO_X, CO, and SO_2) are generated by blasting and from tailpipe exhaust from mining equipment and haul trucks. Emission rates (annual and maximum 24-hour) were estimated using standard emission factor approaches in conjunction with design and operational parameters provided by Peabody Western Coal Company. Vehicle and equipment tailpipe emissions from fuel combustion were based on USEPA's NONROAD emission model, using equipment fleet characteristics for the modeled year. Coal and overburden blasting emissions were calculated using emission factors from AP-42 Section 13.3, which is based on the tons of explosives used in each charge: NO_X = 17 pounds/ton, CO = 67 pounds/ton, and SO_2 = 0.01 pounds/ton. Pollution controls on fugitive particulate matter sources, as applied at the proposed KMC, were taken into account when quantifying pollutant emission rates. The particulate matter emitting sources are listed in **Table 3.1-16**, along with emission factors, controls, and control effectiveness. Emission factors for PM_{10} and $PM_{2.5}$ include adjustments for particle size distribution where appropriate and were included when calculating those emissions.

Annual emission inventories for total suspended particulates, PM_{10}, and $PM_{2.5}$ were developed for each year of the period 2020-2044. Worst-case years for modeling were selected using these inventories and the proposed KMC mine plan maps, as described in MMA (2016 [Section 4.5]), based on the mine operations and proximity to the mine boundaries. Emissions were apportioned to the individual mining and preparation areas for the years modeled.

Table 3.1-16 Particulate Matter Emission Sources, Factors, and Controls

PM Sources	Factor	Factor Reference	Controls	Control Effectiveness
Prep Area				
Truck dumping	0.000294 pounds/ton	USEPA AP-42 Section 13.2.4	None	0
Hopper loading	0.000294 pounds/ton	USEPA AP-42 Section 13.2.4	Water Sprays	50%
Transfer points	2.10 X 10-5 pounds/ton	USEPA AP-42 Section 13.2.4	Water/Chemical+Enclosures	95%
Primary crushing	0.0012 pounds/ton	USEPA AP-42 Table 11.9.2-2	Controlled factor	included
Secondary crushing	0.0012 pounds/ton	USEPA AP-42 Table 11.9.2-2	Controlled factor	included
Screening	0.0022 pounds/ton	USEPA AP-42 Table 11.9.2-2	Controlled factor	included
Sample crushing	0.0030 pounds/ton	USEPA AP-42 Table 11.9.2-2	Controlled factor	included
Wheeled dozers	36.582 pounds/hour	USEPA AP-42 Table 11.9-1	None	0

Table 3.1-16 Particulate Matter Emission Sources, Factors, and Controls

PM Sources	Factor	Factor Reference	Controls	Control Effectiveness
Pile wind erosion	Varies	USEPA AP-42 Section13.2.5	NA	NA
Coal Pit Areas				
Coal removal	0.0021 pounds/ton	WDEQ 1979	None	0
Overburden removal (shovel)	0.015 pounds/ton	WDEQ 1979	None	0
Overburden removal (dragline)	0.030 pounds/yard^3	WDEQ 1979	None	0
Scrapers	26.827 pounds/hour	WDEQ 1979	Watering	50%
Overburden drilling	1.3 pounds/hole	USEPA AP-42 Table 11.9-4	Operations	90%
Overburden blasting	37.5 pounds/blast	WDEQ 1979	None	0
Coal drilling	0.22 pounds/hole	USEPA AP-42 Table 11.9-4	Operations	90%
Coal blasting	26.25 pounds/blast	WDEQ 1979	None	0
Overburden haul roads	2.263 pounds/vehicle mile traveled	WDEQ 1979	Watering/Dust Suppressant	60%
Coal haul roads	4.023 pounds/vehicle mile traveled	WDEQ 1979	Watering/Dust Suppressant	60%
Dozers on Overburden	3.941 pounds/hour	USEPA AP-42 Table 11.9-1	None	0
Graders	26.827 pounds/hour	WDEQ 1979	Watering	50%
Water trucks	1.006 pounds/vehicle mile traveled	WDEQ 1979	Watering/Dust Suppressant	60%
Wind erosion	0.25 ton/acre-year	WDEQ 1979	None	0

WDEQ = Wyoming Department of Environmental Quality.

Source: MMA 2014.

Tables 3.1-17 and **3.1-18** present the total annual emissions from the proposed KMC for the years modeled under the 8.1 million tpy and 5.5 million tpy production, respectively. Note the years modeled for the 8.1 million tpy production rates were 2027 and 2042, while the 5.5 million tpy production was modeled for 2022 and 2043.

Table 3.1-17 Total Emissions for the 8.1 Million tpy Production

Operation or Source	Emissions (tpy)					
	NO_X	CO	SO_2	PM	PM_{10}	$PM_{2.5}$
Year 2027						
Coal preparation facilities	0	0	0	161	46	4.3
Mining fugitive emissions	0	0	0	2,147	633	88
Scoria fugitive emissions	0	0	0	14	4.2	1.2
Blasting	126	498	0.1	5	1.5	0.1
Equipment exhaust	493	37	0.7	8	8	8
Total	619	535	1	2,335	692	101
Year 2042						
Coal preparation facilities	0	0	0	157	45	4.1
Mining fugitive emissions	0	0	0	2,797	817	115
Scoria fugitive emissions	0	0	0	14	4.2	1.2
Blasting	239	943	0.1	5	1.5	0.1
Equipment exhaust	560	31	0.8	8	8	8
Total	799	974	1	2,981	876	128

Source: MMA 2014.

Table 3.1-18 Total Emissions for the 5.5 Million tpy Production

Operation or Source	Emissions (tpy)					
	NO_X	CO	SO_2	PM	PM_{10}	$PM_{2.5}$
Year 2022						
Coal preparation facilities	0	0	0	141	40	3.7
Mining fugitive emissions	0	0	0	1,949	576	81
Scoria fugitive emissions	0	0	0	14	4.2	1.2
Blasting	77	303	0.1	3.3	1.0	0.1
Equipment exhaust	346	50	0.5	8	8	8
Total	423	353	1	2,115	629	94
Year 2043						
Coal preparation facilities	0	0	0	140	39	3.6
Mining fugitive emissions	0	0	0	2,275	670	94
Scoria fugitive emissions	0	0	0	14	4.2	1.2
Blasting	116	456	0.1	3.3	1.0	0.1
Equipment exhaust	364	20	0.5	5	5	5
Total	480	476	1	2,437	719	104

Source: MMA 2014.

3.1.4.3.2.2 Modeled Impacts

AERMOD was applied to calculate airborne concentrations for each pollutant resulting from the proposed KMC emissions for each of the two worst-case years and for each production operation. A combination of volume and area source characterizations was used to represent the mine sources. Haul roads were characterized as a series of volume sources. Receptors for modeling impacts were placed at the proposed KMC boundary and at residences located both inside and outside of the mine lease area. **Figure 3.1-8** depicts the residence receptors. Beyond the boundary, the receptor grid extended over a 100-km by 100-km grid using a set of nested grid receptors as displayed in **Figure 3.1-11**. Background air quality concentrations were based on data collected at the proposed KMC or at regional stations either representative of remote locations or conservative estimates of the regional background. The impacts of emissions from NGS that might overlap with the proposed KMC impacts were accounted for by adding the deposition rates at any receptor at the proposed KMC to the KMC emissions in the proposed KMC analysis. In addition, NGS emissions were included in background concentrations that were used in the NAAQS analysis for the proposed KMC.

Impacts were assessed by selecting the highest modeled design concentration for each respective criteria air pollutant and averaging time at any of the receptors. Most of the maximum impacts would occur near the proposed KMC lease boundary. The maximum modeled design concentrations at the boundary and grid receptors are provided in **Table 3.1-19** and the maximum modeled design concentrations at the residence receptors are provided in **Table 3.1-20**. Emissions from blasting were not included in modeling the 1-hour impacts for NO_2, CO, or SO_2 because they would be intermittent, highly variable, and occur for only a small fraction of any 1-hour period (MMA 2016 [Section 5.6]). All model results indicate that the impacts, including the monitored background concentrations, would be below the ambient air quality standards.

Table 3.1-19 Maximum Modeled Design Concentrations at Proposed KMC Boundary and Grid Receptors

Pollutant	Averaging Time	Modeled Design Concentration ($\mu g/m^3$) 5.5 million tpy	Modeled Design Concentration ($\mu g/m^3$) 8.1 million tpy	Background[1] Concentration ($\mu g/m^3$)	Total Concentration and Percent of NAAQS: 5.5 million tpy ($\mu g/m^3$)	5.5 million tpy (%)	8.1 million tpy ($\mu g/m^3$)	8.1 million tpy (%)	NAAQS ($\mu g/m^3$)
NO_2	1-hour[2]	131.4	146.7	included	131.4	70	146.7	78	188
NO_2	Annual[3]	9.7	8.8	5.6	12.3	12	14.4	14	100
CO	1-hour[4]	64.7	65.8	1,955.0	2,019.7	5	2,020.8	5	40,000
CO	8-hour[4]	3,282.6	3,521.4	1,495.0	4,777.6	48	5,016.4	50	10,000
SO_2	1-hour[5]	0.4	0.7	22.7	23.1	12	23.4	12	195
SO_2	3-hour[4]	1.0	1.6	19.1	20.1	2	20.7	2	1300
PM_{10}	24-hour[6]	50.7	69.4	33.7	84.4	56	103.1	69	150
$PM_{2.5}$	24-hour[7]	6.8	5.7	13.0	19.8	57	18.7	53	35
$PM_{2.5}$	Annual[8]	1.3	1.2	4.7	6.0	50	5.9	49	12

[1] Represents monitored background concentrations, including contributions from NGS.
[2] 5-year mean of 8th highest daily maximum.
[3] Maximum annual over 5 years.
[4] Highest 2nd high over 5 years.
[5] 5-year mean of the 4th highest daily maximum.
[6] Highest 6th high over 5 years.
[7] 5-year mean of the highest 8th high.
[8] Maximum of the 5-year mean.
Source: MMA 2016.

Table 3.1-20 Maximum Modeled Design Concentrations at Proposed KMC Residence Receptors

Pollutant	Averaging Time	Modeled Design Concentration ($\mu g/m^3$)		Background[1] Concentration ($\mu g/m^3$)	Total Concentration and Percent of NAAQS				NAAQS ($\mu g/m^3$)
		5.5 million tpy	8.1 million tpy		5.5 million tpy		8.1 million tpy		
					($\mu g/m^3$)	(%)	($\mu g/m^3$)	(%)	
NO_2	1-hour[2]	114.3	125.5	included	114.3	61	125.5	67	188
NO_2	Annual[3]	5.3	7.8	5.6	10.9	11	13.4	13	100
CO	1-hour[4]	34.8	22.5	1,955.0	1,989.9	5	1,977.5	5	40,000
CO	8-hour[4]	1,615.9	1,82.9	1,495.0	3,110.9	31	2,777.9	28	10,000
SO_2	1-hour[5]	0.18	0.3	22.7	22.9	12	23.0	12	195
SO_2	3-hour[4]	0.6	0.5	19.1	19.7	2	19.6	2	1300
PM_{10}	24-hour[6]	28.7	34.8	33.7	62.4	42	68.5	46	150
$PM_{2.5}$	24-hour[7]	3.4	4.0	13.0	16.4	47	17.0	49	35
$PM_{2.5}$	Annual[8]	0.8	1.0	4.7	5.5	46	5.7	48	12

1 Includes modeled contributions from NGS.

2 5-year mean of 8th highest daily maximum.

3 Maximum annual over 5 years.

4 Highest 2nd high over 5 years.

5 5-year mean of the 4th highest daily maximum.

6 Highest 6th high over 5 years.

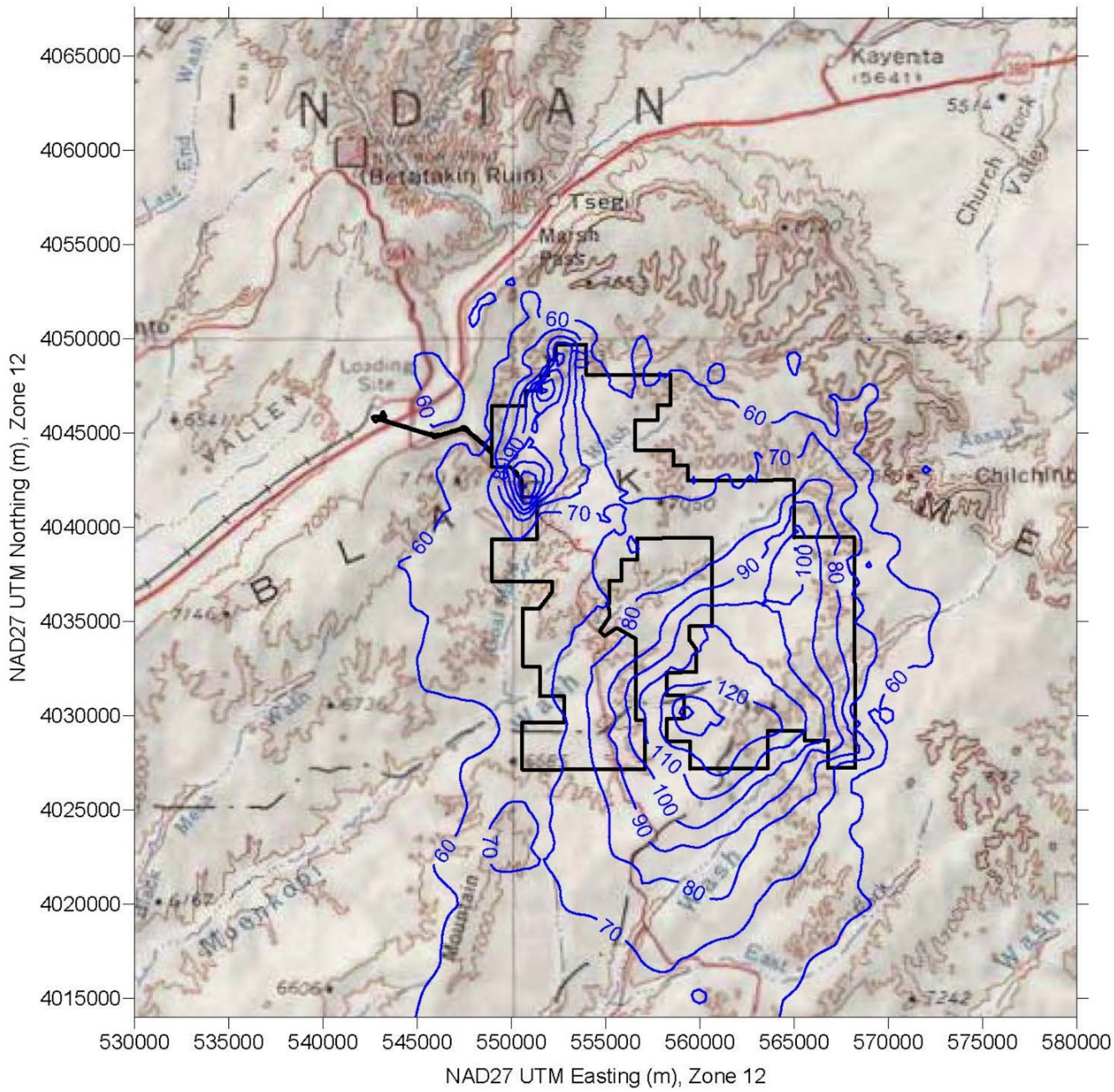
7 5-year mean of the highest 8th high.

8 Maximum of the 5-year mean.

Source: MMA 2016.

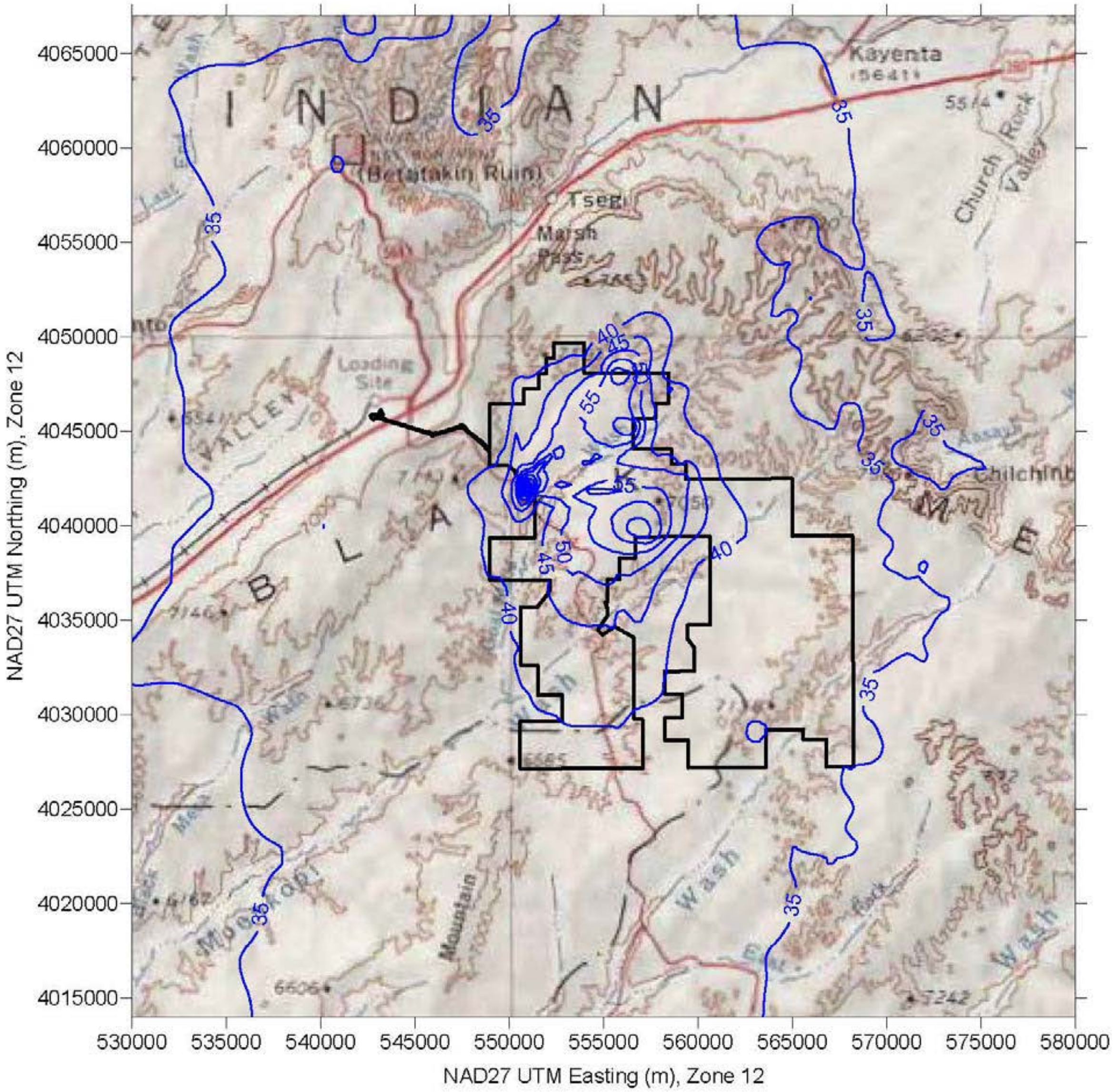
Most of the modeled impacts are less than half the ambient standard. The 1-hour NO_2, 24-hour PM_{10}, and 24-hour $PM_{2.5}$ at the proposed KMC boundary and grid receptors would be above half the NAAQS and up to 78 percent, 69 percent, and 57 percent of the standard, respectively. At the proposed KMC residence receptors, only the NO_2 impacts were above half the NAAQS and up to 67 percent of the standard. For clarity and evaluation, the spatial pattern of impacts for the maximum year of impact are depicted in **Figures 3.1-12** through **3.1-14** for 1-hour NO_2 for 2027, 24-hour PM_{10} for 2042, and 24-hour $PM_{2.5}$ for 2027, respectively. All patterns show that the maximum impacts would be concentrated near specific sources on the mine lease area. The pattern of impacts for other years would be different but still characterized in a similar fashion, with consolidated peak impacts and much lower impacts at the remaining receptors.

The impacts on air quality at the proposed KMC would be minor because impacts for criteria pollutants would be well below the ambient standard. As shown in **Figures 3.1-12** through **3.1-14**, the modeled impacts decrease rapidly with distance from the proposed mining operations.



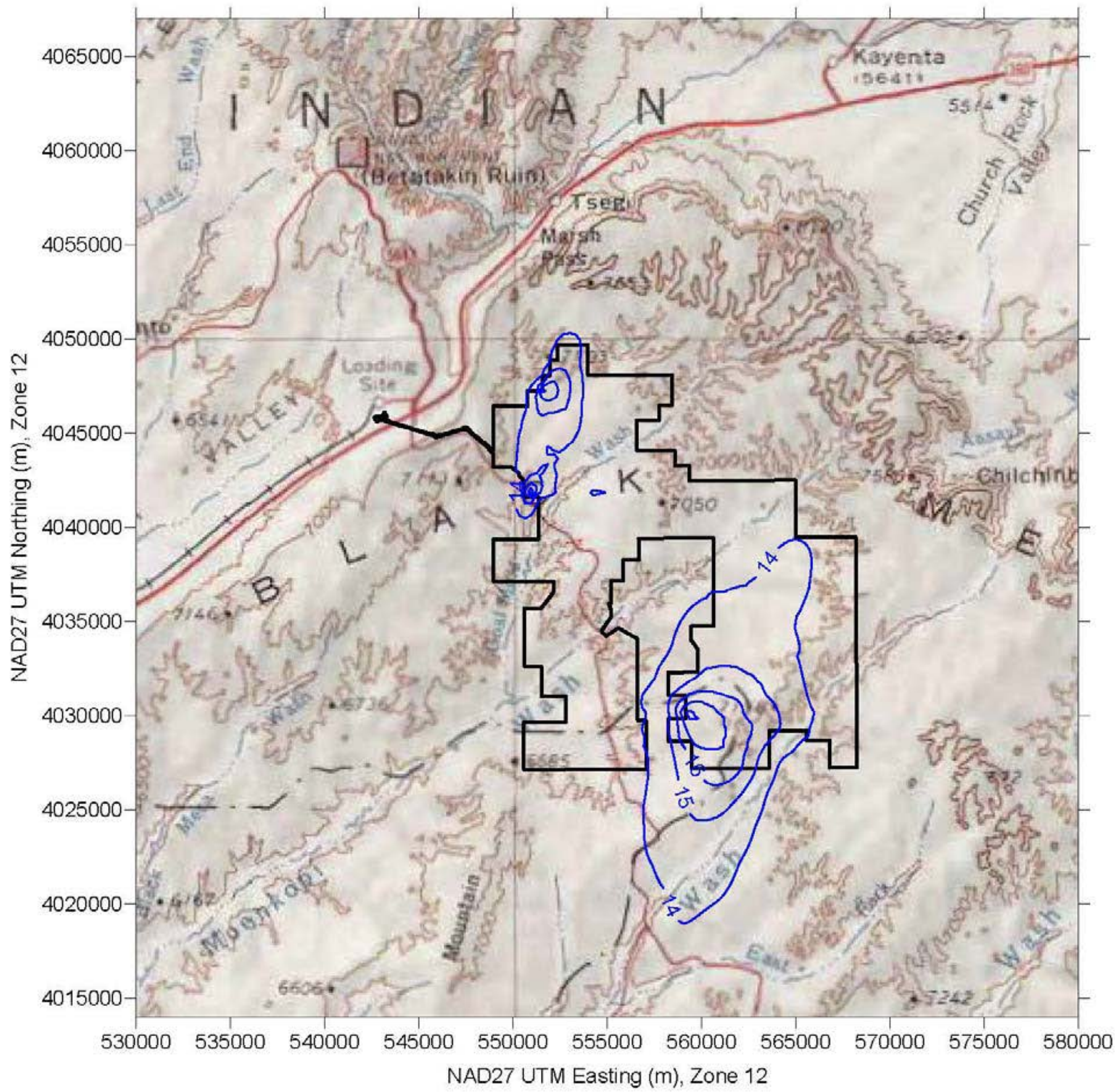
Source: MMA 2016.

Figure 3.1-12 1-hour 5-year Mean 98^th Percentile NO_2 Concentration (µg/m^3) for 8.1 Million tpy Production Operation in 2027



Source: MMA 2016.

Figure 3.1-13 24-hour 6th-High PM_{10} Concentration (μg/m^3) for 8.1 Million tpy Production Operation in 2042



Source: MMA 2016.

Figure 3.1-14 24-hour 5-year Mean 98th Percentile $PM_{2.5}$ Concentration (µg/m^3) for 8.1 Million tpy Production Operation in 2027

3.1.4.3.2.3 Metals Deposition

The AERMOD modeling system also was used to develop estimates of impacts of trace metals at receptors near the proposed KMC that were identified by the ERAs and HHRAs. Total suspended particulate matter emission sources were divided into two source groups: dirt and coal. The dirt group consists of soil/overburden handling, fugitive dust from traffic along haul roads, and fugitive dust from exposed surfaces. Coal sources consist of pit extraction, coal handling and processing, and coal pile wind erosion. Total suspended particulate and PM_{10} impacts were modeled separately for these two source groups. Airborne particulate matter size distribution data were taken from USEPA (1995). AERMOD generated deposition fluxes on an annual basis. Deposition rates for the trace metals were based on a measured fraction of each trace metal concentration in the soil and coal samples.

Total (both wet and dry) deposition of particulate matter was calculated separately for the two source groups (coal and dirt). The deposition rate of particulate matter was multiplied by the respective 95 percentile upper confidence limit of the trace metals concentrations in soil and in coal (Ramboll Environ 2016e [Table X-1a]) to calculate the annual deposition rate for each metal at each receptor for each of the modeled years. Details of the particulate matter size distribution, the 95 percent upper confidence limit, and the total deposition for each of the modeled years for the 8.1 million tpy production operation and the 5.5 million tpy production operation are provided in MMA (2016 [Section 7.0]). Detailed maximum deposition rates for other chemicals of potential concerns are included in MMA (2016 [Section 7.5]). Average basin-wide deposition rates also were calculated for each of 7 different drainage basins near NGS for mercury and selenium. Details of the deposition rates for each of the identified basins are included in MMA (2016 [Table 8-1]).

Table 3.1-21 provides the maximum deposition rates for the primary chemicals of potential concern at any receptor for any phase of the mining operation.

Table 3.1-21 Deposition Rates for Selected Metals from Proposed KMC Operations

Contaminant	Maximum Deposition Rate at Any Receptor and Any Mining Operation (kg/hectare-year)
Arsenic	0.000489
Mercury (total)	0.0000149
Selenium	0.000131

Source: MMA 2016.

The deposition rates for arsenic, mercury, and selenium can be compared to the baseline concentration in soils by using the 95th percentile upper confidence limit for soil (MMA 2016 [Table 7-1]) and the maximum deposition rate (MMA 2016 [Table 7-3]) and calculating the comparative deposition to the concentration using a 2-centimeter soil depth and 1.5 grams per cubic centimeter density of soil. Using this comparison, over 25 years of operation at the maximum level, arsenic and mercury deposition would add less than 1 percent to the baseline soil concentration. Deposition of selenium would add approximately 23 percent to the baseline soil levels. Similar to the depictions of PM_{10} impacts in MMA (2016 [Figures 6-1 and 6-2]), the highest deposition rates would occur near the proposed mining operations and would be half the maximum deposition rates at all but a few receptors off the mine lease area.

PM_{10} air concentrations for the chemicals of potential concern also were calculated from the modeled coal and dirt source groups by applying the respective upper confidence limit for each contaminant. Diesel particulate matter air concentrations from equipment tailpipes also were modeled. Results of the deposition and air concentration modeling for risk assessment receptors for the 8.1 million tpy and 5.5 million tpy production operations were provided to the ERA and HHRA teams for use in their analyses.

The effect of deposition of chemicals of potential concern from the proposed KMC would be negligible as arsenic and mercury deposition would represent less than 1 percent of the baseline soil concentration. Selenium deposition would have a minor impact as it would reach 23 percent of the baseline soil concentrations after 25 years of operation, but the selenium deposition would occur over a very limited area.

3.1.4.3.2.4 Blasting Operations

Given the intermittent nature of mine blasting, the emissions of NO_X from blasting of coal and overburden were not included in modeling the 1-hour NO_2 concentrations. The on-site monitored NO_2 data from near-pit monitoring sites were analyzed to characterize the impacts of blasting on short-term NO_2 concentrations. The blasting data and 1-hour NO_2 monitored levels were tabulated in cases where the blast occurred within a 90-degree upwind sector of a monitor. The data were analyzed for the hour of the blast as well as the subsequent 2 hours.

For the 3-hour period that included the blast hour and the subsequent 2 hours for all cases where the monitor was within ±45 degrees downwind of the blast, the mean NO_2 concentration was 1.8 ppb. For hours when the monitor was within ±20 degrees, the mean concentration was 2.0 ppb. The highest 1-hour NO_2 concentration recorded downwind of a blast for any hour was 24 ppb (45 $\mu g/m^3$). Therefore, NO_2 produced by blasting events at the proposed KMC likely would not reach the 1-hour NO_2 standard of 188 $\mu g/m^3$.

For 1-hour SO_2 and CO, blasting emissions also were not modeled for the same reasons as 1-hour NO_2. However, on-site monitoring of these pollutants is not necessary due to the small amount of SO_2 emissions and the relatively small amount of CO emissions as compared to the high NAAQS value.

The impact of blasting operations on local air quality would have a negligible effect on hourly NO_2 concentrations because the impacts would be well below the ambient standard, and they would occur intermittently and at different locations under a range of meteorological conditions, thereby limiting the impact at any one receptor.

3.1.4.3.2.5 Visibility

No visibility or plume blight analyses were conducted on proposed KMC operations because the emissions would occur over a broad area and typically would not be a plume. Furthermore, emissions generally would be at or near ground level, thereby impeding their rise into the atmosphere and limiting the spatial extent of their impacts.

3.1.4.3.2.6 Reclamation Activities

Under the Proposed Action the mine areas at the proposed KMC would be subject to reclamation activity to restore the surface to a comparable natural habitat of the area. Exposed coal seam areas would be covered, overburden stockpiles removed or leveled, and a surface covering of natural soils and vegetation would be in place. This activity is defined under the approved reclamation plan and would be similar to the overburden handling activities that are in place for normal operations at the mine (Office of Surface Mining Reclamation and Enforcement 2011). Emissions would be associated with heavy equipment operation engine exhaust and fugitive dust emissions associated with wind erosion and overburden replacement including soil transfers, bulldozing, grading, and topsoil replacement. Emissions during reclamation activities would be less than during active mining. Impacts would be minor because they would be localized and likely well below the ambient air quality standards.

3.1.4.3.3 Transmission Systems and Communication Sites

The transmission lines and communication sites would continue to operate at remote locations from NGS and the proposed KMC. The communication sites include propane-fired generators to provide backup power. Many of the sites are operated and maintained by other users. Given the relatively infrequent testing applied to these facilities, the remote locations, and the relatively low emission rates associated with propane fired units, the air quality emissions and impacts on existing air quality conditions would be negligible. Maintenance activities for the communication sites, transmission lines, and access roads would include vehicle traffic (vehicle exhaust and fugitive dust from unpaved roads), but the maintenance activities would be infrequent, short duration, and/or localized (**Appendix 1B**). For example, transmission line structure maintenance and repair would occur on an as-needed basis; routine actions such as vegetation clearing would occur once every 5 years, or less frequently depending on need; repair of access roads and transmission tower infrastructure would occur along localized sections of the lines or roads; and maintenance of access roads would occur once or twice a year, but equipment would move through the areas quickly. Therefore, emissions for future operations would be considered minor, and environmental impacts would be negligible because these impacts would be infrequent, short duration, and localized.

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

3.1.4.3.4 Project Impact Summary – All Project Components

Air quality impacts from the Proposed Action would be below the ambient air quality standards for all criteria air pollutants, based on the existing background concentrations, projected emission rates, and modeled impacts using USEPA guideline air quality modeling protocols. The maximum impacts would be localized near the major emitting sources, and those impacts would be reduced with increasing distance from those sources.

The maximum impacts on air quality would occur very near the facility operations at both NGS and the proposed KMC. However, those maximum impacts would be reduced to less than half of the ambient air quality standard within a few kilometers of each operating source. The levels of impacts for all project components for each of the considered analyses are provided in **Table 3.1-22**.

Short-term moderate increases in fugitive dust and equipment emissions would occur during decommissioning over a 1-year period at NGS and a minimum 10-year period at the proposed KMC starting in 2044.

Table 3.1-22 Proposed Action Impact Summary

Project Component	Impact Parameter	Impact Magnitude
NGS	Air quality (ambient air quality standards)	Moderate because impacts are close to the standards near NGS but decrease with distance.
	Regional haze	Moderate because impacts are above 1.0 deciviews.
	Acid deposition in Class I areas	Negligible because NGS contributions are a few percent.
	Ozone levels	Minor because NGS contributes up to 2 ppb at locations that are well below the standard.

Table 3.1-22 Proposed Action Impact Summary

Project Component	Impact Parameter	Impact Magnitude
Proposed KMC	Air quality	Minor because impacts are well below the standards.
	Deposition of metals	Negligible for arsenic and mercury deposition which are 1 percent of baseline and minor for selenium as deposition would be up to 23 percent of baseline over 25 years, but over a limited area.
	From blasting operations	Negligible because impacts are well below the standards.
Transmission Systems and Communication Sites	Impacts on air quality and air quality values	Negligible because emissions are small and infrequent.

3.1.4.3.5 Cumulative Impacts

As described in Section 3.1.3, regional air quality is good with no non-attainment areas within 300 km of NGS. There are no reasonably foreseeable new sources of air emissions within the 50-km AERMOD modeling area. Local deposition rates for trace metals (mercury, selenium, and arsenic) were calculated, and background regional and global deposition rates from EPRI (2016) were added to the local deposition rate calculations. Other major emission sources within the 300-km region include coal-fired and natural gas power plants, oil and gas compressor stations and gas processing plants, cement plants, and other industrial sources (**Table 3.1-3** and **Figure 3.1-2**). Emissions from regional urban sources, as well as pollutants transported over long distances (e.g., mercury from China) were included in the monitored background concentrations.

The photochemical grid modeling (CAMx) extended to 300 km from NGS and included numerous existing major sources for the period of the Proposed Action (through 2044). The photochemical grid modeling incorporated foreseeable future year updates of emission estimates from other regional sources, including mobile sources, oil and gas exploration and production, and the major power plants in region. Specific changes in emissions from major sources included the planned reductions in emissions associated with the Regional Haze Rule for affected power plants. Ramboll Environ (2016a [Section 3.3.3]) describes the primary sources and anticipated operational changes within the 2020 to 2044 time frame.

Existing sources are depicted in **Figure 3.1-2** and listed in **Table 3.1-3**. Emissions from other major sources for the period of the Proposed Action were based on the following:

- The shutdown of 2 units at the San Juan Generating Station and installation of SCR on the remaining units from 2020 and beyond.
- The shutdown of 3 units at the Four Corners Power plant and installation of SCR on the remaining units beginning in 2014 and continuing operation with those controls past 2020.
- A USEPA database representing the 2025 emissions inventory used to develop the Particulate Matter Rule for NAAQS (USEPA 2016).

Details of the regional inventories are provided in Ramboll Environ (2016a [Section 3.3.3]).

The cumulative impacts on air quality related to the Proposed Action and the action alternatives are discussed by primary constituent. The effects of all cumulative actions include background air quality concentrations, as well as emissions from other sources. The following discussion focuses on the contribution that the Proposed Action makes to the cumulative impacts from all sources included in the far-field modeling (out to 300 km).

3.1.4.3.5.1 Criteria Pollutants

The modeled concentrations of criteria pollutants (NO_2, CO, SO_2, PM_{10}, $PM_{2.5}$, and lead) at the highest Proposed Action output (i.e. 3-Unit Operation) were in compliance with air quality standards within the 50-km near-field modeling study area. There are no identified existing permitted nearby sources and no reasonably foreseeable new sources within the near-field modeling study area that would affect the highest predicted concentrations near NGS or the proposed KMC.

Table 3.1-23 and **Table 3.1-24** present summaries of the cumulative results at near-field air modeling receptors 50 km and 80 km away from the NGS, respectively (Ramboll Environ2016f). Typically, the near-field modeling techniques used to assess the NAAQS are applied to receptor distances within 50 km. However to support the EIS Human Health Risk Assessment and Ecological Risk Assessment, and to characterize regional impacts, receptors also were considered at 80 km from NGS.

The methods used in the simulations and derivation of background concentrations representative of all other cumulative sources were presented in Ramboll Environ (2016b). The NGS contributions included in **Table 3.1-23** and **Table 3.1-24** are from the simulations of the 3-Unit Operation pre-SCR installation case with the highest emissions, which result in the highest modelled impacts.

The results show that estimated cumulative concentrations are much lower than the NAAQS at 50 km and are even further reduced at 80 km from NGS. Maximum impacts are generally toward the East and East-Northeast of NGS. Concentrations would be reduced further beyond 80 km. Moreover, the near-field modeling results from AERMOD are conservative especially with regard to the 1-hour standards as they reflect worst case meteorological conditions and maximum emission rates. Also, it is very unlikely that peak concentrations from NGS will overlap both in time and space with the peak contributions of other cumulative sources that are farther away and potentially subject to different wind patterns. As shown in **Tables 3.1-23** and **3.1-24**, the highest cumulative impacts are toward the east, in the direction of two other major coal fired power plants, including the Four Corners Power Plant on Navajo Nation lands in New Mexico. In an Environmental Impact Statement for the Four Corners Power Plant (OSMRE 2015, [Table 4.1-41]) cumulative modeled results showed compliance with the ambient air quality standards in the vicinity of that plant.

For the reasons mentioned above, it is highly unlikely that NGS would contribute to cumulative concentrations near the NAAQS at distances beyond 80 km

3.1.4.3.5.2 Deposition

Dispersion and deposition of trace metals from NGS stacks (including mercury, selenium, and arsenic) were assessed in detail for the ERAs (Sections 3.8 through 3.13) and HHRAs (Section 3.16). The NGS contribution to the regional deposition pattern, including cumulative sources, varies by metal. The deposition and fate of mercury has been studied in detail within a region that includes Lake Powell (EPRI 2016). The 3-Unit Operation would contribute between 1.7 and 2.2 percent of the annual deposition from all sources (12.7 micrograms per square meter). At this location, approximately 16 percent of the deposition is from China, approximately 81 percent from the rest of the world, and less than 1 percent from other regional sources within 300 km of NGS. A similar pattern was observed at a receptor point in Lake Powell, where NGS would contribute less than 1 percent of the cumulative deposition.

Table 3.1-23 Cumulative Results from Near-field Modeling for Receptors 50 km from NGS

Pollutant	NAAQS Primary or Secondary Standard (µg/m^3)	Averaging Time	Highest Predicted Conc. due to NGS at 50 km in any Direction (µg/m^3) [1]	Background (µg/m^3)	Cumulative Concentration (µg/m^3)	NGS % of NAAQS	Total Conc. % of NAAQS	Bearing from NGS Plant
NO_2	188	1-hour	***	Varies [2]	112.3	***	60%	ENE
NO_2	100	Annual	1.25	6	7.2	1%	7%	E
CO	40,000	1-hour	84.4	3,664	3,748.4	0%	9%	E
CO	10,000	8-hour	26.8	2,633.5	2,660.3	0%	27%	ENE
SO_2	196	1-hour	50.1	22.5	72.6	26%	37%	E
SO_2	1,310	3-hour	30.4	24.6	55.0	2%	4%	NE
PM_{10}	150	24-hour	1.08	44.5	45.6	1%	30%	E
$PM_{2.5}$	35	24-hour	0.499	20.8 [3]	21.3	1%	61%	E
$PM_{2.5}$	12	Annual	0.0909	5.9 [4]	6.0	1%	50%	E
Lead	0.15	3-month	0.00002	0.01	0.0	0%	7%	E

[1] NGS contributions based on design concentration for the worst year and rank by pollutant and averaging period as follows: SO_2 1-hour: 4th high, SO_2 Annual: 1st high, NO_2 1-hour: 8th high, NO_2 Annual: 1st high, CO 1-hour and 8-hour: 2nd high, PM_{10} 24-hour: 6th high over 5 years, $PM_{2.5}$ 24-hour: 8th high, $PM_{2.5}$ Annual: 1st high, and Lead 3-Month: 1st high.

[2] NO_2 1-hour was modeled in AERMOD with seasonal, hourly background values.

[3] $PM_{2.5}$ 24-hour background includes 1.0 µg/m^3 secondary aerosol formation from CAMx simulation.

[4] $PM_{2.5}$ annual background includes 0.26 µg/m^3 secondary aerosol formation from CAMx simulation.

Table 3.1-24 Cumulative Results from Near-field Modeling for Receptors 80 km from NGS

Pollutant	NAAQS Primary or Secondary Standard (µg/m³)	Averaging Time	Highest Predicted Conc. due to NGS at 80 km in any direction (µg/m³) [1]	Background (µg/m³)	Cumulative Concentration (µg/m³)	NGS % of NAAQS	Total Conc. % of NAAQS	Bearing from NGS Plant
NO_2	188	1-hour	***	Varies [2]	76.4	***	41%	E
NO_2	100	Annual	0.655	6	6.7	1%	7%	E
CO	40,000	1-hour	43.8	3,664	3,707.8	0%	9%	E
CO	10,000	8-hour	9.50	2,633.5	2,643.0	0%	26%	E
SO_2	196	1-hour	28.5	22.5	51.0	15%	26%	E
SO_2	1310	3-hour	12.1	24.6	36.7	1%	3%	E
PM_{10}	150	24-hour	0.506	44.5	45.0	0%	30%	E
$PM_{2.5}$	35	24-hour	0.287	20.8 [3]	21.1	1%	60%	E
$PM_{2.5}$	12	Annual	0.0478	5.9 [4]	5.9	0%	50%	E
Lead	0.15	3-Month	0.00001	0.01	0.0	0%	7%	E

[1] NGS contributions based on design concentration for the worst year and rank by pollutant and averaging period as follows: SO_2 1-hour: 4th high, SO_2 Annual: 1st high, NO_2 1-hour: 8th high, NO_2 Annual: 1st high, CO 1-hour and 8-hour: 2nd high, PM_{10} 24-hour: 6th high over 5 years, $PM_{2.5}$ 24-hour: 8th high, $PM_{2.5}$ Annual: 1st high, and Lead 3-Month: 1st high.

[2] NO_2 1-hour was modeled in AERMOD with seasonal, hourly background values.

[3] $PM_{2.5}$ 24-hour background includes 1.0 µg/m³ secondary aerosol formation from CAMx simulation.

[4] $PM_{2.5}$ annual background includes 0.26 µg/m³ secondary aerosol formation from CAMx simulation.

For arsenic and selenium, NGS is the primary regional air emission source for both metals. Deposition rates decline sharply over a 50-km distance from NGS, with low level concentrations across the Northeast Gap Region that includes Lake Powell and the San Juan River watershed. See Section 3.0 for a discussion of how ecological and human health risk study areas were defined. This pattern is similar to that of the criteria pollutants discussed above. In summary, these metals would not substantially contribute to cumulative impacts with other existing and foreseeable regional emissions sources, as NGS emissions represent only 2 to 9 percent of the total mercury deposition and 0.44 percent of total selenium deposition. Deposition for these metals results primarily from other sources outside of the regional study area.

3.1.4.3.5.3 Regional Haze

Installation of SCR controls as part of the Proposed Action would meet the requirement of the Federal Implementation Plan that was promulgated to improve cumulative visibility impacts in Class I areas, taking into account cumulative impacts from all sources and including stationary industrial sources and other sources such as distant urban emissions, wildfires, and sea salt.

3.1.4.3.5.4 Ozone and Air Quality-related Values

Air quality conditions and impacts beyond the range of the AERMOD modeling analysis were conducted with the photochemical grid model CAMx (Ramboll Environ 2016a). This model evaluated impacts on ozone and acid-deposition within 300 km of NGS, including assessment of visibility impacts at designated Class II locations (Ramboll Environ 2016c). Impacts on acid deposition at Class I areas also were addressed in this modeling effort. The model domain included several Class I areas (National Parks and designated Wilderness Areas) and sensitive Class II areas. The inner grid of receptors for this model, along with the Class I and sensitive Class II areas are depicted in **Figure 3.1-1**.

Details of the CAMx modeling effort, including assumptions, setup, and input data are included in Ramboll Environ (2016c [Section 2.0]). The input meteorological and source characterization data were taken from the 2008 WestJUMP Air Quality Management Study (Environ and Alpine 2012). This is a standard gridded database of the 2008 meteorological database along with emissions data for major sources and area sources embedded for model performance evaluation. Modeled emissions from non-NGS sources included mobile, non-road, area, point, fire, and biogenic emission sources. The model was run for a Base Case using the 2008 data to provide a Model Performance Evaluation, which documented the accuracy of predicted actual ambient concentrations from a database of actual emissions. The same emissions data set was used to develop the regional emissions database for future operations as well, with adjustments for known changes in point source emissions, using the USEPA emission profile for 2020 developed for USEPA modeling of sources to comply with a new ambient standard for $PM_{2.5}$. Emissions from biogenic sources, fires, lightning, sea salt, and fugitive dust sources that contribute to cumulative impacts were unchanged from the 2008 database, along with emissions from Mexico and Canada.

The CAMx model was run using the NGS emissions for the 3-Unit Operation and the 2-Unit Operation, with individual model runs for NGS emissions both prior to and following SCR installation for both options. The model also was designed to run in a source apportionment mode so that any of the impacts could be re-evaluated to determine what source(s) contribute the largest portion to any impact.

3.1.4.3.5.5 Impacts on Ozone Levels

The CAMx model produced a spatial depiction of impacts on ozone levels in the region, for both the pre-SCR and post-SCR operations. The spatial pattern was developed using the USEPA Modeled Attainment Test Software (Abt 2009; USEPA 2015b). The largest impacts were associated with the 3-Unit Operation from emissions prior to the installation of SCR on NGS. The results show isolated areas of slightly elevated high ozone levels, but overall compliance with the ambient standard level. Prior to the installation of SCR, the NGS contribution to the design value above 1 ppb would be limited to an area to the east and north of the facility, with a maximum ozone design value contribution of 2.3 ppb. Following installation of SCR, the nearby impact on ozone levels would be reduced to a maximum receptor impact of 1.6 ppb. For the 2-Unit Operation the impacts would be reduced from the 3-Unit Operation impacts with a maximum of 2.1 ppb prior to the installation of SCR and 1.3 ppb following installation of SCR. Compared to the impacts from the 3-Unit Operation, the extent of the area where NGS impact would be above 1 ppb would be reduced for both the 2-Unit Operation and for installation of SCR on both 3-Unit Operation and 2-Unit Operation.

The cumulative ozone design value impacts would be 76 ppb (i.e., above 70 ppb standard) in southern Coconino County, in Maricopa County, and at receptors in Southern Apache County; however, the contribution from NGS to the ozone levels at these locations would be 0.0 to 0.4 percent of the total ozone levels.

The future operation of NGS under the Proposed Action would not cause an exceedance of the ambient air quality standard within the 50-km near-field study area for ozone. Isolated areas within the regional 300-km study area would experience major impacts from ozone, where ozone concentrations would exceed the NAAQS. However, NGS would provide a negligible contribution to these exceedances, representing only up to 0.4 percent of the total. Cumulative impacts on ozone levels would be considered major because there are several locations in the study area where those impacts would be above the ambient standard; however, those impacts would result from emissions from other sources.

3.1.4.3.5.6 Ozone Impacts at Class I and Identified Sensitive Class II Areas

Model results for a range of predicted maximum design value ozone impacts for each of the identified Class I areas are provided in **Table 3.1-25**. The table provides the No Action Alternative impact for comparison to the range of impacts from the Proposed Action. In this case, the NGS 3-Unit Operation for 2020 prior to installation of the SCR would result in the maximum NGS impact contribution, and the NGS 2-Unit Operation following installation of SCR would result in the lowest impact contribution. NGS 3-Unit Operation or 2-Unit Operation, both prior to and following SCR installation, would result in negligible effects on ozone levels. The highest impacts would be at Grand Canyon National Park, where NGS impact contributions would range from 0.4 to 0.5 ppb. At most of the other Class I areas, impacts would be between 0.0 and 0.3 ppb, with even less of a difference between the 3-Unit Operation and 2-Unit Operation, including pre- and post-SCR installation. In demonstrating compliance with the 8-hour ozone standard, the 3-year average of the annual fourth highest daily values in ppm is expressed to three decimal places (or whole ppb values). For example a calculated average of 70.9 ppb (0.0709 ppm) would be shown as 70 ppb (0.070 ppm) and therefore would be compliant with the standard (40 CFR 50 Appendix U paragraph 3(e)). None of the predicted concentrations in **Table 3.1-25** would be above the ambient standard because the data are truncated to 3 decimal places in ppm (or whole ppb).

Table 3.1-25 Range of Maximum Ozone Impacts of NGS Operation at Class I Areas

		Ozone Concentration (ppb)			
		2020 3-Unit Operation Pre-SCR Installation		2030 2-Unit Operation Post-SCR Installation	
Class I Area	No Action	Cumulative	NGS Only	Cumulative	NGS Only
Arches National Park	69.6	69.7	0.1	69.7	0.1
Bryce Canyon National Park	68.2	68.1	-0.1	68.2	0.0
Canyonlands National Park	70.1	70.2	0.1	70.1	0.0
Capitol Reef National Park	68.5	68.8	0.3	68.7	0.2
Grand Canyon National Park	70.0	70.5	0.5	70.2	0.2
Mazatzal Wilderness Area	66.1	66.2	0.1	66.1	0.0
Mesa Verde National Park	68.6	68.6	0.0	68.6	0.0

Table 3.1-25 Range of Maximum Ozone Impacts of NGS Operation at Class I Areas

Class I Area	No Action	Ozone Concentration (ppb)			
		2020 3-Unit Operation Pre-SCR Installation		2030 2-Unit Operation Post-SCR Installation	
		Cumulative	NGS Only	Cumulative	NGS Only
Petrified Forest National Park	64.8	64.9	0.1	64.9	0.1
Pine Mountain Wilderness Area	63.5	63.6	0.1	63.5	0.0
Sycamore Canyon Wilderness Area	67.1	67.3	0.2	67.3	0.2
Zion National Park	68.3	68.6	0.3	68.4	0.1

Source: Ramboll Environ 2016a.

Model results for the range of predicted ozone levels for each of the identified sensitive Class II areas are provided in **Table 3.1-26.** Similar to the results for Class I areas, the table provides the No Action Alternative impact for comparison to the range of impacts from the Proposed Action. The NGS 3-Unit Operation or 2-Unit Operation, prior to and following SCR installation, would result in negligible effect on maximum ozone levels at these areas. The largest NGS impacts would be at the Pine Valley Mountain Wilderness Area and Wupatki National Monument, where NGS would contribute 0.3 ppb for the 3-Unit Operation prior to SCR installation, and 0.1 ppb for the 2-Unit Operation after SCR installation. The maximum contribution for 2030 with the 2-Unit Operation at any site would be 0.1 ppb.

Table 3.1-26 Range of Maximum Ozone Impacts of NGS Operation at Sensitive Class II Areas

Sensitive Class II Area	No Action	Ozone Concentration (ppb)			
		2020 3-Unit Operation Pre-SCR Installation		2030 2-Unit Operation Post-SCR Installation	
		Cumulative	NGS Only	Cumulative	NGS Only
Ashdown George Wilderness	69.6	69.6	0.0	69.6	0.0
Box-Death Hollow Wilderness	69.1	69.2	0.1	69.1	0.0
Canyon DeChelly National Monument	67.7	67.9	0.2	67.8	0.1
Chaco Culture National Historic Park	65.1	65.1	0.0	65.1	0.0
Cottonwood Forest Wilderness	66.8	67.0	0.2	66.9	0.1
Dark Canyon Wilderness	69.3	69.4	0.1	69.3	0.0
Glen Canyon National Recreation Area	70.0	70.1	0.1	70.0	0.0
Natural Bridges National Monument	68.4	68.5	0.1	68.5	0.1
Pine Valley Mountain Wilderness	67.0	67.3	0.3	67.1	0.1
Wupatki National Monument	67.5	67.8	0.3	67.6	0.1

Source: Ramboll Environ 2016a.

Ozone levels would be in compliance with the ambient air quality standard at all sensitive Class II areas and Class I areas. The maximum impacts associated with the 3-Unit Operation prior to installation of SCR at Grand Canyon National Park would comply with, but would be just less than, the NAAQS at Grand Canyon National Park, representing a moderate cumulative impact. However, NGS would represent less than 1 percent of the total cumulative impact. Impacts from the 2-Unit Operation would be equivalent or slightly less than the impacts from the 3-Unit Operation. In general the impacts of the

Proposed Action on ozone levels would be minor because they would be within the typical range of variability in the study area.

3.1.4.3.5.7 Acid Deposition

Emissions of SO_2 and NO_X are converted by atmospheric processes to ground-level deposition of acidic sulfur and nitrogen compounds, both through wet deposition during precipitation events and dry deposition occurring as particles that are deposited on the earth and water surfaces. Wet and dry deposition of sulfur and nitrogen containing compounds were evaluated with the CAMx model throughout the modeling domain, and included specific analyses at Class I areas and sensitive Class II areas.

In the vicinity of NGS (i.e., within 50 km), total sulfur deposition would be up to 3 kg/hectare-year for the 3-Unit Operation prior to and after installation of SCR. Similar patterns would occur for the 2-Unit Operation but with slightly less deposition for both sulfur and nitrogen. Maximum total nitrogen deposition would be approximately 1 to 4 kg/hectare-year for the 3-Unit Operation, and the footprint would be reduced following installation of SCR because of the reduced emission rate of NO_X from the main stacks. Total sulfur deposition could increase slightly following installation of SCR because the ammonia slip from SCR operation would react with SO_2 to produce a sulfate compound, which enhances deposition of total sulfur.

Total annual average sulfur deposition also was calculated at receptors in selected nearby Class I areas for the 3-Unit Operation both before and after SCR installation. Arches National Park has the lowest cumulative total annual average deposition rate of all listed areas, averaging 0.24 kg/hectare-year for the 3-Unit Operation. The highest cumulative modeled deposition rate was at the Pine Mountain Wilderness Area with average deposition of 0.70 kg/hectare-year. The NGS average contribution to deposition would be greatest at Bryce Canyon National Park with 0.03 kg/hectare-year for those receptors for the 3-Unit Operation. The modeled deposition rate at the maximum impact receptor at Bryce Canyon National Park was 0.037 kg/hectare-year.

Total modeled cumulative annual average deposition rates of nitrogen compounds in the Class I Areas ranged from 1.64 kg/hectare-year at Canyonlands National Park to 3.64 kg/hectare-year at the Mazatzal Wilderness Area. The maximum impact from NGS operations would occur at Capitol Reef National Park at 0.06 and 0.02 kg/hectare-year for pre- and post-SCR installation, respectively. The analyses clearly indicate that the NGS contribution to either sulfur or nitrogen deposition at the Class I areas would be about 3 percent or less of the No Action cumulative deposition rate at Bryce Canyon National Park and other nearby Class I areas, and much less than that at more distant Class I areas. A slight reduction in average impacts at Class I areas nearest to NGS would occur following the installation of SCR, with a greater reduction seen for nitrogen deposition than for sulfur deposition.

The deposition rates also were evaluated at 59 separate lakes and streams in Arizona, Colorado, and Utah. An analysis of the critical load of acidity for sulfur and nitrogen was prepared. Cumulative acid deposition exceeded the critical load at only one waterbody, the Anasazi Pond near Spillway, Utah (which was 0.45 kg/hectare-year for sulfur deposition and 2.17 kg/hectare-year for nitrogen deposition). This would be a major cumulative impact at this one location, but NGS contribution would be negligible at approximately 2 to 3 percent of the total cumulative deposition. For all other waterbodies, the nitrogen and sulfur deposition were below the critical load, and the contribution from NGS generally would be approximately 0.1 percent of the critical load, with some deposition rates from NGS of approximately 1 to 2 percent of the critical load. As a result, the Proposed Action would have a negligible impact on acidic deposition at these locations.

A total of 111,307 forest data locations were examined for nitrogen and sulfur acid deposition compared to critical loads of acidity. Exceedances of critical load from cumulative impacts were noted at 9 of the sites, which were all in the Upper Gila Mountains. The contribution from NGS and the proposed KMC was approximately 0.3 percent of the total for the 3-Unit Operation and 0.2 percent of the total for the 2-Unit Operation.

Empirical critical loads for nitrogen deposition at 11 Class I areas were obtained from Pardo et al. (2011) and the National Atmospheric Deposition Program CLAD database (National Atmospheric Deposition Program 2015b). Following Ellis et al. (2013), the critical loads for the most sensitive ecosystem receptor were identified in the North American Deserts ecoregion. The critical load for lichens and lower critical load for herbaceous species and shrubs were evaluated at the 11 Class I areas, both for cumulative impacts and for the contribution from the Proposed Action. The maximum cumulative nitrogen deposition exceeded the critical loads for lichens and the lower critical load for herbaceous species (3 kg/hectare-year) at 7 of the 11 areas and was as high as 5.5 kg/hectare-year at Zion National Park. These would be considered major cumulative impacts. The contribution from the Proposed Action at these areas ranged from 0.4 to 3.2 percent for the 3-Unit Operation and from 0.2 to 2.5 percent for the 2-Unit Operation prior to the installation of SCR; therefore, the NGS contribution to the cumulative impact would be negligible. Impacts of nitrogen deposition would be further reduced with the installation of SCR for both operations and would be considered negligible.

Impacts of nitrogen and sulfur deposition from NGS operations would be largest near (within 10 km) NGS and decrease with distance from the facility. Proposed Action impacts from deposition of these compounds on the Class I areas and the identified Class II areas would range from negligible to a few percent of the total deposition rates for both species. Nitrogen impacts from NGS operations following the installation of SCR would be reduced proportionally to the reduction in NO_X emissions and would remain negligible.

There are no major permitted air quality sources near the proposed KMC; therefore, there would be no overlapping or spatially cumulative impacts. Air quality emissions and impacts would be directly related in time and would not accumulate except for deposition of trace metals and other particulate matter. The deposition rates and impacts are discussed further for the ERAs and HHRAs.

3.1.4.3.5.8 Transmission Systems and Communication Sites

Emissions of criteria pollutants associated with small transmission line maintenance crews would widely dispersed in space and time. It is estimated that approximately 100 pounds of criteria pollutants and three tons of CO_2 equivalent would be emitted by light duty vehicles driving 2,000 miles annually. The Western Transmission System maintenance activities would overlap with construction of transmission lines and pipelines in the same utility corridor and access roads in northern Arizona and southern Nevada. This would result in short-term (months) local increases in criteria pollutant and greenhouse gas emissions from diesel and gasoline internal combustion engines where project activities overlap. There are no foreseen overlapping projects associated with the Southern Transmission System.

Because there are no foreseeable actions that would intersect the communication sites within the geographic space and time frame of the Proposed Action, there would be no cumulative impacts to air quality.

3.1.4.3.5.9 Cumulative Impacts Summary

The magnitude of cumulative impacts for each of the considered analyses are provided below and represent the maximum cumulative impact levels in the study area, along with the contribution from the Proposed Action. Project contributions to regional cumulative impacts would be negligible (generally less than 1 percent) at the local scale. NGS emissions would not interact with any other nearby large fossil-fuel source. At a regional scale, cumulative impacts would be major for ozone and regional haze when all sources are considered. Cumulative impacts for acid deposition would be moderate to major.

Air Quality Impacts	Moderate based on the maximum impacts around NGS but minor elsewhere in the study area, based on levels well below the ambient standard as shown in **Table 3.1-4**.
Regional Haze	Moderate, given the impacts would remain above 1.0 deciviews following installation of SCR.
Acid Deposition	Moderate given that cumulative deposition would exceed 3 kg/hectare-year at 4 of the Class I areas, but would be below 8 kg/hectare-year at all Class I areas. NGS contribution is less than 1 percent at these locations and would be negligible. Acid deposition at forest locations would be minor; well below the critical load except at 9 out of 111,307 sites and at one of 59 lakes and streams. However, the cumulative impacts at some locations would be major because the critical load for nitrogen would be exceeded at 7 of the 11 Class I sites, and the critical load for sulfur and nitrogen would be exceeded at one of 59 lakes and streams.
Ozone Levels	Major for cumulative impacts due to the predicted exceedances of the standard at locations in the study area; however, NGS contribution at those receptors would be negligible.

3.1.4.4 Natural Gas Partial Federal Replacement Alternative

3.1.4.4.1 Navajo Generating Station

Under the Natural Gas PFR Alternative, a selected quantity of power between 100 megawatts (MW) and 250 MW would be contracted for under a long-term power purchase agreement from currently unidentified, existing natural gas generation sources, displacing an equivalent amount of power from the federal share of NGS generation. For this replacement power, the total emissions from the natural gas-fired unit were estimated from a permit analysis for the Bowie Power Plant in Arizona (Arizona Department of Environmental Quality 2014). That facility is a 1,050-MW (nominal) natural gas-fired, combined cycle power plant.

Table 3.1-27 provides a comprehensive air quality overview of the Natural Gas PFR Alternative, including total emissions from NGS and the replacement facility for criteria air pollutants and selected HAPs. The impacts provided in **Table 3.1-27** include only the impacts from NGS added to background concentrations for criteria air pollutants and do not include impacts for the replacement facility because they would not overlap under this alternative. Arizona Department of Environmental Quality (2014) determined that all air quality impacts (except for the 1-hour NO_2 impact) from the Bowie Power Plant were below the established impact limit for major source permitting under federal rules (40 CFR Part 52.21). The scaled 1-hour NO_2 impact for 100 MW of power would be approximately 11.2 $\mu g/m^3$, which is approximately 6 percent of the ambient standard. Unless the replacement power would be provided by a source that is near another major source, that impact likely would be minor and localized. Therefore, impacts from a replacement facility were not analyzed further for this alternative.

The maximum impacts at NGS are dominated by surface level operations (e.g., mobile heavy equipment, coal and ash handling systems); therefore, there would be no difference in impacts for the range of power generation with the exception of SO_2, which is dominated by the emissions from the main stacks. There also would be little difference in maximum impacts when compared to the range of impacts associated with the Proposed Action. The impacts on ozone levels, acid deposition in Class I areas, and plume visibility at the maximum impacted vista would represent NGS impacts only. The NGS impacts shown in **Table 3.1-27** are conservative because they generally represent the modeled maximum impact across pre-SCR and post-SCR conditions.

Table 3.1-27 Emissions and Impacts from NGS Associated with the Natural Gas PFR Alternative

Parameter		Emissions / Impacts			
		3-Unit Operation		2-Unit Operation	
		100-MW Replacement	250-MW Replacement	100-MW Replacement	250-MW Replacement
(NGS Main Stack plus Natural Gas Replacement Emissions of Criteria Pollutants and Selected HAP Metals (tons/year)					
Pre-SCR NO_X		19,461	18,039	12,658	11,236
Post-SCR NO_X		6,542	6,151	4,274	3,883
CO		14,056	13,274	9,197	8,415
SO_2		9,231	8,500	5,992	5,260
PM_{10}		1,972	1,826	1,282	1,136
$PM_{2.5}$		1,419	1,317	932	821
VOC		233	216	152	135
Arsenic		0.127	0.117	0.083	0.073
Mercury		0.111	0.102	0.072	0.063
Selenium		2.127	1.957	1.377	1.208
NH_3 Pre-SCR		0	0	0	0
NH_3 Post-SCR		42	38	27	24
H_2SO_4 Pre-SCR		45	41	29	25
H_2SO_4 Post-SCR		366	336	204	179
NGS Support Facility Emissions (tons/year)					
NO_X		56	52	46	41
CO		22	20	19	19
SO_2		1	1	1	1
PM_{10}		97	89	86	74
$PM_{2.5}$		14	13	13	11
VOC		6	5	5	4
Maximum Short-term Impacts (µg/m^3) and Air Quality Standards (shaded)					
1-hour NO_2	188	186.3	186.3	186.3	186.3
1-hour CO	40,000	4,402.8	4,402.8	4,402.8	4,402.8
1-hour SO_2	196	156.7	146.3	111.0	100.6
3-hour SO_2	1,300	101.9	95.7	74.6	68.4
24-hour PM_{10}	150	138.6	138.4	137.5	137.3
24-hour $PM_{2.5}$	35	32.7	32.7	32.6	32.6
8-hour ozone (ppb)	70	2.3	2.2	2.1	2.0

Table 3.1-27 Emissions and Impacts from NGS Associated with the Natural Gas PFR Alternative

Parameter		Emissions / Impacts			
		3-Unit Operation		2-Unit Operation	
		100-MW Replacement	250-MW Replacement	100-MW Replacement	250-MW Replacement
Maximum Annual Average Impacts ($\mu g/m^3$) and Air Quality Standards (shaded)					
Pre-SCR NO_2	100	20.1	19.5	17.8	17.2
Post-SCR NO_2	100	18.1	17.7	16.6	16.2
$PM_{2.5}$	12	7.6	7.5	7.4	7.3
Maximum Acid Deposition Rate (kg/hectare-year)					
Sulfur Deposition		0.035	0.032	0.023	0.020
Nitrogen Deposition		0.057	0.053	0.038	0.034

Shaded numbers represent the NAAQS.

Annual power production from NGS would be reduced by 100 MW to 250 MW, resulting in a reduction in power generation at NGS ranging from of 5 to 13 percent for the 3-Unit Operation and 8 to 19 percent for the 2-Unit Operation (**Table 3.0-4**). This reduction would be applied to the annual emissions of pollutants from the main stacks; however, maximum daily emissions under this alternative could be the same as the Proposed Action for the 3-Unit Operation and 2-Unit Operation because there would be no associated restriction on a daily basis. The maximum short-term (daily and hourly) impacts for all pollutants (except SO_2) near the NGS ambient air quality boundary would be roughly the same for the 3-Unit Operation and 2-Unit Operation because the emissions are dominated by surface level operations and would be just below the ambient standards (except that CO impacts would be well below the standards). For SO_2 impacts, the daily and 1-hour maximum impacts could be the same as the individual 3-Unit Operation and 2-Unit Operation given that the hourly operations would not be restricted by the Natural Gas PFR Alternative. Maximum annual impacts for the Natural Gas PFR Alternative for NO_2 prior to installation of SCR would be reduced by a range of approximately 1.5 to 5 percent. (See **Tables 3.1-12** and **3.1-13** for the Proposed Action values.) Annual impacts on $PM_{2.5}$ levels would be roughly identical for the 3-Unit Operation and 2-Unit Operation and would be just below the ambient standards. Impacts from NGS on air quality for this alternative would be considered moderate because of high impacts locally near the facility.

3.1.4.4.2 Proposed Kayenta Mine Complex

Under the Natural Gas PFR Alternative, mining operations at the proposed KMC would be reduced relative to the power generation reductions at NGS (**Table 3.0-6**). The environmental consequences of the Natural Gas PFR Alternative at the proposed KMC would be related to annual and daily coal production. Although the PFR alternatives were not specifically analyzed for air emissions or modeled for impacts to air quality, an estimate of those emissions and impacts was calculated based on the change in total coal production for each alternative. The impacts would be reduced from the 3-Unit Operation impacts based on the ratio of the reduced coal production to the difference in coal production for the 3-UnitOperation and 2-Unit Operation. Similar to the analysis for NGS, the range of impacts from the Natural Gas PFR Alternative would correspond to the reduction of 100-MW to 250-MW energy production at NGS. Emissions or impacts for the Natural Gas PFR at the proposed KMC do not include emissions or impacts from the replacement source of power, as the facility associated with the replacement would be negligible for all pollutants as discussed for NGS. Additionally, the replacement facility likely would be far away from the proposed KMC. **Table 3.1-28** provides a summary of annual and daily emissions and impacts associated with the Natural Gas PFR. Maximum impacts are provided separately for receptors off the proposed KMC lease area and for residence receptors on the proposed KMC lease area. All data are based on the maximum impact at any of the group receptors. Impacts would be well below the NAAQS and considered minor.

Table 3.1-28 Emissions and Impacts of the Proposed KMC Operations Associated with the Natural Gas PFR Alternative

Parameter		Emissions / Impacts			
		3-Unit Operation		2-Unit Operation	
		100-MW Replacement	250-MW Replacement	100-MW Replacement	250-MW Replacement
KMC Emissions of Criteria Pollutants (ton/year)					
NO_X		588	542	392	344
CO		506	463	324	280
SO_2		1	1	1	1
PM_{10}		682	667	619	604
$PM_{2.5}$		100	98	93	91
KMC Emissions of Criteria Pollutants (pounds per day)					
NO_X		28,257	27,753	26,118	25,606
CO		84,894	84,929	85,044	85,080
SO_2		23	22	19	18
PM_{10}		7,621	7,205	5,855	5,431
$PM_{2.5}$		1,128	1,072	890	833
Maximum Impact at Off-site Receptors ($\mu g/m^3$) and Air Quality Standards (shaded)					
1-hour NO_2	188	144.3	140.7	128.9	125.3
Annual NO_2	100	14.1	13.6	12.0	11.5
1-hour CO	40,000	2,020.6	2,020.4	2,019.5	2,019.3
8-hour CO	10,000	4,978.8	4,922.4	4,739.3	4,681.9
1-hour SO_2	196	23.4	23.3	23.1	23.0
3-hour SO_2	1,300	20.6	20.5	20.0	19.9
24-hour PM_{10}	150	100.2	95.7	81.4	76.9
24-hour $PM_{2.5}$	35	18.9	19.1	20.0	20.2
Annual $PM_{2.5}$	12	5.9	5.9	6.0	6.0
Maximum Impact at Residence Receptors ($\mu g/m^3$) and Air Quality Standards (shaded)					
1-hour NO_2	188	123.7	121.1	112.5	109.8
Annual NO_2	100	13.0	12.4	10.5	9.9
1-hour CO	40,000	1,979.5	1,982.4	1,991.9	1,994.9
8-hour CO	10,000	2,830.3	2,908.9	3,164.3	3,244.4
1-hour SO_2	196	23.0	23.0	22.9	22.9
3-hour SO_2	1,300	19.6	19.6	19.7	19.7
24-hour PM_{10}	150	67.5	66.1	61.4	60.0
24-hour $PM_{2.5}$	35	16.9	16.8	16.3	16.2
Annual $PM_{2.5}$	12	5.7	5.6	5.5	5.4

Shaded numbers represent the NAAQS.

3.1.4.4.3 Transmission System and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance. Emissions and impacts would be the same as under the Proposed Action.

3.1.4.4.4 Project Impact Summary – All Project Components

Although the emissions from NGS operations would lead to slight impacts near the proposed KMC operations, the maximum impacts for each operation would not be affected by those emissions. Therefore, the combined maximum impacts from all project components for the Natural Gas PFR Alternative would be based on the maximum impacts individually at NGS and the proposed KMC. More specifically the maximum impacts at NGS and the proposed KMC would not be substantially affected by the overlap between the two operations. The impacts from the proposed KMC on receptors near NGS would be negligible in comparison to the direct impacts from NGS. Similarly the impacts of NGS on the proposed KMC operations would be much smaller than the impacts directly around NGS; however, an effort was made to add impacts from NGS main stack emissions to the background concentration used in estimating impacts at the proposed KMC. The emissions from the Natural Gas PFR Alternative would be considered moderate for NGS and minor for the proposed KMC, similar to the Proposed Action.

3.1.4.4.5 Cumulative Impacts

Cumulative impacts resulting from the Natural Gas PFR Alternative would be reflected in the impacts for NGS and the proposed KMC as provided above. The dispersion modeling analysis included background air quality concentrations for analyzing compliance with the NAAQS, and the combination of the modeled source impacts added to the background would represent the cumulative impacts for all sources. Impacts from the replacement facility would occur at a separate location near that facility and would be negligible (as noted above) except potentially for 1-hour NO_2 impacts. Without detailed information about the site, topography, stack and source parameters, and background concentration, the impact on 1-hour NO_2 levels cannot be characterized.

Maximum cumulative impacts on ozone levels in the study area would occur at a location in southern Coconino County, near Flagstaff, Arizona. That design-value impact is approximately 76 ppb for both the 3-Unit Operation and 2-Unit Operation, with a reduction calculated to be 0.1 ppb following the installation of SCR at NGS. Given that the maximum impact would not change for the 3-Unit Operation and 2-Unit Operation, there would be no detectable impact on cumulative maximum ozone levels for the Natural Gas PFR Alternative.

The maximum cumulative sulfur deposition would be in southern Apache County in Arizona, with a deposition rate of 21.2 kg sulfur/hectare-year for the 3-Unit Operation. The maximum cumulative nitrogen deposition would occur in northwestern McKinley County in New Mexico, near the Arizona border. The total nitrogen deposition rate would be approximately 30.5 kg nitrogen/hectare-year at that location. The selection of this Natural Gas PFR Alternative would not have an effect on the maximum cumulative acid deposition levels because of the negligible (less than 1 percent) contribution of NGS to total deposition at these locations.

3.1.4.5 Renewable Partial Federal Replacement Alternative

3.1.4.5.1 Navajo Generating Station

Under the Renewable PFR Alternative, a selected quantity of power between 100 MW and 250 MW would be contracted for under a long-term power purchase agreement from a currently unidentified, existing renewable energy power source, displacing an equivalent amount of power from the federal share of NGS generation. The Renewable PFR Alternative assumes that this installation would require firming power generation and those emissions are included in **Table 3.1-29**. See Section 2.2.3 for details regarding firming power.

Table 3.1-29 Emissions and Impacts from NGS Associated with the Renewable PFR Alternative

Parameter		Emissions / Impacts			
		3-Unit Operation		2-Unit Operation	
		100-MW Replacement	250-MW Replacement	100-MW Replacement	250-MW Replacement
NGS Main Stack plus Natural Gas Firm Power Emissions of Criteria Pollutants and Selected HAP Metals (tons/year)					
Pre-SCR NO_X		19,811	18,914	13,008	12,111
Post-SCR NO_X		6,606	6,310	4,338	4,042
CO		14,156	13,524	9,297	8,665
SO_2		9,433	9,004	6,193	5,764
PM_{10}		2,009	1,918	1,319	1,229
$PM_{2.5}$		1,443	1,378	947	882
VOC		237	226	156	145
Arsenic		0.130	0.124	0.086	0.080
Mercury		0.114	0.108	0.075	0.069
Selenium		2.174	2.075	1.424	1.325
NH_3 Pre-SCR		0	0	0	0
NH_3 Post-SCR		43	41	28	26
H_2SO_4 Pre-SCR		46	44	30	28
H_2SO_4 Post-SCR		374	357	211	197
NGS Support Facility Emissions (tons/year)					
NO_X		57	55	48	44
CO		22	21	23	21
SO_2		1	1	1	1
PM_{10}		99	94	89	83
$PM_{2.5}$		14	14	13	12
VOC		6	6	5	4
Maximum Short-term Impacts ($\mu g/m^3$) and Air Quality Standards (shaded)					
1-hour NO_2	188	186.3	186.3	186.3	186.3
1-hour CO	40,000	4,402.8	4,402.8	4,402.8	4,402.8
1-hour SO_2	196	159.6	153.5	113.9	107.8
3-hour SO_2	1,300	103.6	100.0	76.3	72.7
24-hour PM_{10}	150	138.7	138.6	137.6	137.5
24-hour $PM_{2.5}$	35	32.7	32.7	32.6	32.6

Table 3.1-29 Emissions and Impacts from NGS Associated with the Renewable PFR Alternative

Parameter		Emissions / Impacts			
		3-Unit Operation		2-Unit Operation	
		100-MW Replacement	250-MW Replacement	100-MW Replacement	250-MW Replacement
8-hour Ozone (ppb)	70	2.3	2.3	2.1	2.1
Maximum Annual Average Impacts ($\mu g/m^3$) and Air Quality Standards (shaded)					
Pre-SCR NO_2	100	20.2	19.9	17.9	17.6
Post-SCR NO_2	100	18.2	18.0	16.7	16.5
$PM_{2.5}$	12	7.6	7.6	7.4	7.4
Sulfur Deposition		0.036	0.034	0.024	0.022
Nitrogen Deposition		0.058	0.056	0.039	0.037

Shaded numbers represent the NAAQS.

The maximum air quality impacts are provided in **Table 3.1-29**, but include only the impacts from NGS added to the background concentrations for the criteria air pollutants. Except for SO_2, the maximum impacts at NGS would be generated by surface level operations (e.g., mobile heavy equipment, coal and ash handling systems). As a result, there would be is no reduction in impacts from these emissions for the range of power generation when compared to the range of impacts associated with the Proposed Action. The maximum impacts from NGS on ozone levels, acid deposition in Class I areas, and plume visibility at the maximum impacts vista are shown for NGS impacts only.

Annual power production from NGS would be reduced on an average basis, resulting in a reduction in power generation at NGS in a range of 3 to 7 percent for the 3-Unit Operation and 4 to 11 percent for the 2-Unit Operation (**Table 3.0-4**). This reduction could be applied to the annual emissions of pollutants from the main stacks; however, maximum daily emissions under this alternative could be the same as the Proposed Action for the 3-Unit Operation and 2-Unit Operation because there would be no associated restriction on a daily basis. The maximum short-term (daily and hourly) impacts for all pollutants (except SO_2) near the NGS ambient air quality boundary would be roughly the same for the 3-Unit Operation and 2-Unit Operation because the emissions are dominated by surface level operations and would be just below the ambient standards. For SO_2 impacts, the daily and 1-hour maximum impacts could remain the same as the individual 3-Unit Operation and 2-Unit Operation because hourly operations would not be restricted by the Renewable PFR Alternative. Annual maximum impacts for the Renewable PFR Alternative for NO_2 prior to installation of SCR would be reduced by a range of approximately 1 to 3 percent. (See **Tables 3.1-12** and **3.1-13** for the Proposed Action values.) Annual impacts on $PM_{2.5}$ levels would be roughly identical for the 3-Unit Operation and 2-Unit Operation and would be just below the ambient standards. Impacts from NGS on air quality for this alternative would be considered moderate because of high impacts locally near the facility.

3.1.4.5.2 Proposed Kayenta Mine Complex

Under the Renewable PFR Alternative, mining operations at the proposed KMC would be reduced relative to the power generation reduction at NGS (**Table 3.0-6**). The environmental consequences of the Renewable PFR Alternative at the proposed KMC would be related to annual and daily coal production. Although of the PFR alternatives were not specifically analyzed for air emissions or modeled for impacts to air quality, an estimate of those emissions and impacts was calculated based on the change in total coal production for each alternative. The method for estimating emissions and impacts for the Renewable PFR Alternative was identical to those used for the Natural Gas PFR Alternative. **Table 3.1-30** provides a summary of annual and daily emissions and impacts associated with the Renewable PFR Alternative. Maximum impacts are provided separately for receptors off the proposed KMC lease area and for residence receptors on the proposed KMC lease area. All data are based on the maximum impact at any of the group receptors. Impacts would be well below the NAAQS and considered minor.

Table 3.1-30 Emissions and Impacts of the Proposed KMC Operations Associated with the Renewable PFR Alternative

Parameter		Emissions / Impacts			
		3-Unit Operation		2-Unit Operation	
		100-MW Replacement	250-MW Replacement	100-MW Replacement	250-MW Replacement
Proposed KMC Emissions of Criteria Pollutants (ton/year)					
NO_X		601	574	405	377
CO		518	493	336	311
SO_2		1	1	1	1
PM_{10}		686	678	623	614
$PM_{2.5}$		100	99	93	92
KMC Emissions of Criteria Pollutants (pounds per day)					
NO_X		28397	28103	26261	25962
CO		84884	84904	85034	85055
SO_2		24	23	20	19
PM_{10}		7737	7494	5972	5726
$PM_{2.5}$		1143	1111	906	873
Maximum Impact at Off-site Receptors (µg/m^3) and Air Quality Standards (shaded)					
1-hour NO_2	188	145.3	143.2	130.0	127.8
Annual NO_2	10 0	14.2	13.9	12.1	11.8
1-hour CO	40,000	2020.7	2020.5	2019.6	2019.4
8-hour CO	10,000	4994.5	4961.7	4755.3	4721.8
1-hour SO_2	196	23.4	23.3	23.1	23.0
3-hour SO_2	1,300	20.6	20.6	20.0	20.0
24-hour PM_{10}	150	101.4	98.8	82.7	80.0
24-hour $PM_{2.5}$	35	18.8	19.0	19.9	20.1
Annual $PM_{2.5}$	12	5.9	5.9	6.0	6.0
Maximum Impact at Residence Receptors (µg/m^3) and Air Quality Standards (shaded)					
1-hour NO_2	188	124.5	122.9	113.3	111.7
Annual NO_2	100	13.2	12.8	10.7	10.3
1-hour CO	40,000	1978.6	1980.3	1991.1	1992.8
8-hour CO	10,000	2808.4	2854.2	3142.0	3188.6

Table 3.1-30 Emissions and Impacts of the Proposed KMC Operations Associated with the Renewable PFR Alternative

Parameter		Emissions / Impacts			
		3-Unit Operation		2-Unit Operation	
		100-MW Replacement	250-MW Replacement	100-MW Replacement	250-MW Replacement
1-hour SO_2	196	23.0	23.0	22.9	22.9
3-hour SO_2	1,300	19.6	19.6	19.7	19.7
24-hour PM_{10}	150	67.9	67.1	61.8	61.0
24-hour $PM_{2.5}$	35	16.9	16.9	16.3	16.3
Annual $PM_{2.5}$	12	5.7	5.7	5.5	5.5

Shaded numbers represent the NAAQS.

3.1.4.5.3 Transmission System and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance. Emissions and impacts would be the same as the Proposed Action.

3.1.4.5.4 Project Impact Summary – All Project Components

Although the emissions from NGS operations would lead to slight impacts near the proposed KMC operations, the maximum impacts for each operation would not be affected by those emissions. Therefore, the combined maximum impacts from all project components for the Renewable PFR Alternative would be based on the maximum impacts individually at NGS and the proposed KMC, and would be considered moderate levels of impact, similar to the Natural Gas PFR.

3.1.4.5.5 Cumulative Impacts

Cumulative impacts resulting from the Renewable PFR Alternative would be reflected in the impacts for NGS and the proposed KMC as provided above. The dispersion modeling analysis included background air quality concentrations for analyzing compliance with the NAAQS, and the combination of the modeled source impacts added to the background would represent the cumulative impacts for all sources. Impacts from power generated by the replacement facility would be negligible and well below the impact level established for major source air permitting; therefore, it was not included in the cumulative analysis.

Maximum cumulative impacts on ozone levels in the study area would occur at a location in southern Coconino County, near Flagstaff, Arizona. That design-value impact is approximately 76 ppb for both the 3-Unit Operation and 2-Unit Operation, with a reduction calculated to be 0.1 ppb following the installation of SCR at NGS. Given that the maximum impact would not change for the 3-Unit Operation and 2-Unit Operation, there would be no detectable impact on cumulative maximum ozone levels based on the Renewable PFR Alternative.

Similar to the Natural Gas PFR Alternative, the Renewable PFR Alternative would not have an effect on the maximum acid deposition levels.

3.1.4.6 Tribal Partial Federal Replacement Alternative

3.1.4.6.1 Navajo Generating Station

Under the Tribal PFR Alternative, between 100 MW and 250 MW of power generation from the NGS would be replaced by power supplied by a new photovoltaic generation facility on tribal land, displacing an equivalent amount of power from the federal share of NGS generation. The Tribal PFR facility would be analyzed in a separate National Environmental Policy Act process once a facility location is identified. Similar to the Renewable PFR Alternative, the Tribal PFR Alternative assumes that this installation would require firming power generation.

A transmission line may need to be constructed to support this alternative. Construction emissions would briefly affect air quality, but would be limited in area and duration. Air quality impacts from the transmission line operation would be negligible compared to the NAAQS; similar to the emissions and impacts associated with the Proposed Action.

The impacts provided in **Table 3.1-31** include only the impacts from NGS added to the background concentrations for the criteria air pollutants. Except for SO_2, the maximum impacts at NGS would be generated by surface level operations (e.g., mobile heavy equipment, coal and ash handling systems). As a result, there would be no reduction in impacts for these pollutants when compared to the range of impacts associated with the Proposed Action. The maximum impacts from NGS on ozone levels, acid deposition in Class I areas, and plume visibility at the maximum impacted vista are shown for NGS impacts only.

Table 3.1-31 Emissions and Impacts from NGS Associated with the Tribal PFR Alternative

Parameter	Emissions / Impacts			
	3-Unit Operation		2-Unit Operation	
	100-MW Replacement	250-MW Replacement	100-MW Replacement	250-MW Replacement
NGS Main Stack plus Natural Gas Firm Power Emissions of Criteria Pollutants and Selected HAP Metals (tons/year)				
Pre-SCR NO_X	20,019	19,436	13,216	12,633
Post-SCR NO_X	6,674	6,482	4,406	4,214
CO	14,303	13,892	9,444	9,033
SO_2	9,533	9,263	6,293	6,013
PM_{10}	2,009	1,971	1,340	1,281
$PM_{2.5}$	1,443	1,416	963	920
VOC	237	232	158	151
Arsenic	0.130	0.128	0.087	0.084
Mercury	0.114	0.111	0.076	0.072
Selenium	2.174	2.153	1.447	1.383
NH_3 Pre-SCR	0	0	0	0
NH_3 Post-SCR	43	42	28	27
H_2SO_4 Pre-SCR	46	45	30	29
H_2SO_4 Post-SCR	378	367	211	204

Table 3.1-31 Emissions and Impacts from NGS Associated with the Tribal PFR Alternative

Parameter		Emissions / Impacts			
		3-Unit Operation		2-Unit Operation	
		100-MW Replacement	250-MW Replacement	100-MW Replacement	250-MW Replacement
NGS Support Facility Emissions (tons/year)					
NO_X		58	56	49	46
CO		23	22	23	22
SO_2		1	1	1	1
PM_{10}		100	97	90	86
$PM_{2.5}$		15	15	14	13
VOC		6	6	5	5
Maximum Short-term Impacts (µg/m^3) and Air Quality Standards (shaded)					
1-hr NO_2	188	186.3	186.3	186.3	186.3
1-hr CO	40,000	4402.8	4402.8	4402.8	4402.8
1-hr SO_2	196	161.0	157.0	115.3	111.3
3-hr SO_2	1,300	104.4	102.1	77.1	74.8
24-hr PM_{10}	150	138.7	138.6	137.6	137.5
24-hr $PM_{2.5}$	35	32.7	32.7	32.6	32.6
8-hour Ozone (ppb)	70	2.3	2.3	2.1	2.1
Maximum Annual Average Impacts (µg/m^3) and Air Quality Standards (shaded)					
Pre-SCR NO_2	100	20.3	20.1	18.0	17.8
Post-SCR NO_2	100	18.2	18.1	16.7	16.6
$PM_{2.5}$	12	7.6	7.6	7.4	7.4
Maximum Acid Deposition (kg/hectare-year)					
Sulfur Deposition		0.036	0.035	0.024	0.023
Nitrate Deposition		0.059	0.057	0.040	0.038

Shaded numbers represent the NAAQS.

Annual power production from NGS would be reduced on an average basis, resulting in a reduction in power generation at NGS in a range of 2 to 5 percent for the 3-Unit Operation and 3 to 8 percent for the 2-Unit Operation (**Table 3.0-4**). This reduction could be applied to the annual emissions of pollutants from the main stacks; however, maximum daily emissions under this alternative could be the same as the Proposed Action for the 3-Unit Operation and 2-Unit Operation because there would be no associated restriction on a daily basis. The maximum short-term (daily and hourly) impacts for all pollutants (except SO_2) near the NGS ambient air quality boundary would be roughly the same because the emissions are dominated by surface level operations and would be just below the ambient standards. For SO_2 impacts, the daily and 1-hour maximum impacts could remain the same as the individual 3-Unit Operation and 2-Unit Operation because hourly operations would not be restricted by the Tribal PFR Alternative. Annual maximum impacts for the Tribal PFR Alternative for NO_2 prior to installation of SCR would be reduced by a range of less than 1 to 2 percent. (See **Tables 3.1-12** and **3.1-13** for the Proposed Action values.) Annual impacts on $PM_{2.5}$ levels would be roughly identical for the 3-Unit

Operation and 2-Unit Operation and would be just below the ambient standards. Impacts from NGS on air quality for this alternative would be considered moderate because of high impacts locally near the facility.

3.1.4.6.2 Proposed Kayenta Mine Complex

Under the Tribal PFR Alternative, mining operations at the proposed KMC would be reduced relative to the power generation reduction at NGS (**Table 3.0-6**). The environmental consequences of the Tribal PFR Alternative at the proposed KMC would be related to annual and daily coal production. Although the PFR alternatives were not specifically analyzed for air emissions or modeled for impacts to air quality, an estimate of those emissions and impacts was calculated based on the change in total coal production for each alternative. The method for estimating the emissions and impacts for the Tribal PFR Alternative was identical to that used for the Natural Gas PFR Alternative. **Table 3.1-32** provides a summary of annual and daily emissions and impacts associated with the Tribal PFR Alternative. Maximum impacts are provided separately for receptors off the proposed KMC lease area and for residence receptors on the proposed KMC lease area. All data are based on the maximum impact at any of the group receptors. Impacts would be well below the NAAQS and considered minor.

Table 3.1-32 Emissions and Impacts of the Proposed KMC Operations Associated with the Tribal PFR Alternative

Parameter		Emissions / Impacts			
		3-Unit Operation		2-Unit Operation	
		100-MW Replacement	250-MW Replacement	100-MW Replacement	250-MW Replacement
Proposed KMC Emissions of Criteria Pollutants (ton/year)					
NO_X		607	590	411	393
CO		524	508	342	325
SO_2		1	1	1	1
PM_{10}		688	683	625	619
$PM_{2.5}$		101	100	94	93
Proposed KMC Emissions of Criteria Pollutants (pounds per day)					
NO_X		28,465	28,274	26,330	26,136
CO		84,879	84,892	85,029	85,043
SO_2		24	23	20	19
PM_{10}		7,793	7,635	6,030	5,869
$PM_{2.5}$		1,151	1,130	914	892
Maximum Impact at Off-site Receptors ($\mu g/m^3$) and Air Quality Standards (shaded)					
1-hour NO_2	188	145.8	144.4	130.5	129.1
Annual NO_2	100	14.3	14.1	12.2	12.0
1-hour CO	40,000	2,020.7	2,020.6	2,019.6	2,019.5
8-hour CO	10,000	5,002.2	4,980.8	4,763.1	4,741.3
1-hour SO_2	196	23.4	23.4	23.1	23.1
3-hour SO_2	1,300	20.7	20.6	20.1	20.0
24-hour PM_{10}	150	102.0	100.3	83.3	81.6
24-hour $PM_{2.5}$	35	18.8	18.9	19.9	20.0
Annual $PM_{2.5}$	12	5.9	5.9	6.0	6.0

Table 3.1-32 Emissions and Impacts of the Proposed KMC Operations Associated with the Tribal PFR Alternative

Parameter		Emissions / Impacts			
		3-Unit Operation		2-Unit Operation	
		100-MW Replacement	250-MW Replacement	100-MW Replacement	250-MW Replacement
Maximum Impact at Residence Receptors (µg/m^3) and Air Quality Standards (shaded)					
1-hour NO_2	188	124.8	123.8	113.6	112.6
Annual NO_2	100	13.3	13.0	10.7	10.5
1-hour CO	40,000	1,978.2	1,979.4	1,990.7	1,991.8
8-hour CO	10,000	2,797.8	2,827.6	3,131.1	3,161.5
1-hour SO_2	196	23.0	23.0	22.9	22.9
3-hour SO_2	1,300	19.6	19.6	19.7	19.7
24-hour PM_{10}	150	68.1	67.6	62.0	61.5
24-hour $PM_{2.5}$	35	17.0	16.9	16.4	16.3
Annual $PM_{2.5}$	12	5.7	5.7	5.5	5.5

Shaded numbers represent the NAAQS.

3.1.4.6.3 Transmission System and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

Emissions and impacts would be the same as the Proposed Action unless transmission lines or communication sites needed to be constructed to service the replacement facilities. Temporary air quality emissions from construction operations would occur, but likely would be negligible compared to the NAAQS.

3.1.4.6.4 Project Impact Summary – All Project Components

Although the emissions from NGS operations would lead to slight impacts near the proposed KMC operations, the maximum impacts for each operation would not be affected by those emissions. Therefore, the combined maximum impacts from all project components for the Tribal PFR Alternative would be based on the maximum impacts individually at NGS and the proposed KMC.

3.1.4.6.5 Cumulative Impacts

Cumulative impacts resulting from the Tribal PFR Alternative would be reflected in the impacts for NGS and the proposed KMC as provided above. The dispersion modeling analysis included background air quality concentrations for analyzing compliance with the NAAQS, and the combination of the modeled source impacts added to the background would represent the cumulative impacts for all sources. Construction of the Tribal PFR Alternative would generate temporary air quality emissions, as would construction of any transmission line or other support systems to service the replacement facility. Those emissions would be temporary, and if controlled by an array of practices, likely would not exceed the NAAQS. Impacts from operation of the firming facility would be negligible and well below the impact level established for major source air permitting.

Maximum cumulative impacts on ozone levels in the study area would occur at a location in southern Coconino County, near Flagstaff, Arizona. That design-value impact is approximately 76 ppb for both the

3-Unit Operation and 2-Unit Operation, with a reduction calculated to be 0.1 ppb following the installation of SCR at NGS. Given that the maximum impact would not change for the 3-Unit Operation and 2-Unit Operation, there would be no detectable impact on cumulative maximum ozone levels based on the Tribal PFR Alternative.

Similar to the Natural Gas PFR Alternative, the Tribal PFR Alternative would not affect the maximum cumulative acid deposition levels.

3.1.4.7 No Action

3.1.4.7.1 Navajo Generating Station

With the No Action Alternative, power production at NGS would cease and all associated emissions and impacts from future operations would not occur. However, immediately following cessation of operations, there may be site closure and remediation activities that would generate emissions and lead to nearby impacts.

The ambient air quality conditions associated with the No Action Alternative at NGS would be represented by the assumed background concentrations related to dispersion modeling, except for those pollutants whose background concentrations were determined from the Glen Canyon monitor. The air quality for those pollutants could be slightly improved compared to existing conditions. The background data resources are discussed in Section 3.1.3 and reproduced in **Table 3.1-33** for the air quality around NGS. Short-term background conditions were based on the regulatory approach that applies to the standard (e.g., the 3-year average of the 99th percentile daily maximum 1-hour SO_2 level). The 1-hour NO_2 background was calculated for each seasonal hour, and the three-year average of the 2nd or 3rd highest ozone levels was used to characterize background 1-hour NO_2 levels. Ozone background levels were based on data collected at the Grand Canyon National Park and would be representative of the undeveloped area around the NGS site. Detailed discussion of the background concentrations is provided in Ramboll Environ (2016b [Section 4 and Table 4-1]). All data show compliance with the ambient air quality standards. Under the No Action Alternative, emissions of HAPs from NGS operations would cease. Impacts of soil and water-based chemicals of concern would continue based on the levels of those chemicals that exist within the soil; however, following any remedial activity no additional accumulation of those chemicals would occur.

Table 3.1-33 Background Ambient Air Quality Levels at NGS Representative of the No Action Alternative

Parameter	Background Concentration ($\mu g/m^3$)	Monitor Location	Years
1-hour NO_2	51 (max seasonal)	Hurricane, St. George, UT	2012-2014
1-hour CO	2,634	JGL Supersite, Phoenix area	2008-2012
1-hour SO_2	22.5	Glen Canyon Monitor	2008-2012
24-hour PM_{10}	44.5	Glen Canyon Monitor	2008-2012
24-hour $PM_{2.5}$	20.8	Glen Canyon Monitor	2008-2012
8-hour Ozone (ppb)	68.1	Grand Canyon	2008-2012
Annual NO_2	6.0	Hurricane, UT	2012-2014
Annual $PM_{2.5}$	5.9	Glen Canyon Monitor	2008-2012

3.1.4.7.2 Proposed Kayenta Mine Complex

Under the No Action Alternative, the proposed KMC operations would cease. Temporary emissions would be associated with reclamation activities until the site has received final bond release. Air quality levels measured as background concentrations at the proposed KMC capture both the occasional impacts from the proposed KMC operations when the wind direction transports the mining emissions to the monitor, and the measured concentrations would represent the No Action Alternative conditions when the wind is blowing from other directions. As a result the background concentrations used for modeling would provide a conservative estimate of air quality conditions following closure of the mine (**Table 3.1-19**).

3.1.4.7.3 Transmission Systems and Communication Sites

The NGS transmission system is an established part of the western U.S. transmission grid and supports reliability and delivery of power throughout the region, well beyond the power generated by the NGS. Therefore, under all alternatives it is likely that that one, several, or all of the land owners/managers of the transmission line rights-of-way and communication site leases would renew some portion of the facilities to keep the power grid performing as expected.

In the event it is determined that some or all of the transmission systems and communication site ROWs are not renewed, a lengthy study and permitting process would need to occur before any decommissioning is initiated due to the essential and integral nature of these facilities with the western electric grid. As noted in Section 2.3.3, up to 4,826 acres within and alongside the transmission system corridors could be temporarily disturbed if the entirety of the transmission systems and communication sites were decommissioned and removed resulting in minor, localized emissions impacts.

3.1.4.7.4 Project Impact Summary – All Project Components

As demonstrated above, the existing air quality conditions are in compliance with the NAAQS in the study area. Background concentration data are identified above and would provide the best estimate of air quality conditions for the No Action Alternative. The modeled maximum impacts of emissions, especially near the NGS and proposed KMC operations would not occur. The regional impacts on ozone, acid deposition, and haze levels also would not occur; however, the regional maxima for ozone and acid deposition would not be affected because they are located at distances far from NGS and the proposed KMC, where those impacts are generally less than 1 percent of the observed or modeled impacts.

Short-term moderate increases in fugitive dust and equipment emissions would occur during decommissioning operations at both NGS (2018 to 2019) and the Kayenta Mine (over a minimum 10-year period starting in 2 019).

3.1.5 References

Abt Associates. 2009. Modeled Attainment Test Software. Prepared for Office of Air Quality Planning and Standards. U.S. Environmental Protection Agency.

Arizona Department of Environmental Quality (ADEQ). 2014. Draft Technical Support Document. Technical Review and Evaluation of Application for Air Quality Permit No. 58787. Bowie Power Plant LLC.

Colorado State University (CSU). 2016. IMPROVE and RHR Summary Data. Internet website: http://vista.cira.colostate.edu/improve/Data/IMPROVE/summary_data.htm. Accessed July 24, 2016.

Colorado State University (CSU). 2014a. Federal Land Managers Database. Internet website: http://views.cira.colostate.edu/fed/sitebrowser/default.aspx. Accessed May 24, 2016.

Colorado State University (CSU). 2014b. IMPROVE and RHR Summary Data. Internet website: http://vista.cira.colostate.edu/improve/Data/IMPROVE/summary_data.htm. Accessed July 24, 2016.

Colorado State University (CSU). 1993. IMPROVE Newsletter, Volume 2, No. 1. Winter 1993 (April 1993). Internet website: http://vista.cira.colostate.edu/improve/publications/NewsLetters/apr_93.pdf. Accessed May 24, 2016.

Electric Power Research Institute (EPRI). 2016. A Case Study Assessment of Trace Metal Atmospheric Emissions and Their Aquatic Impacts in the San Juan River Basin. Phase 2: Navajo Generating Station. 3002006244. R. Goldstein and L. Levin. Final Report. April 2016.

Ellis, R. A., D. J. Jacob, M. P. Sulprizio, L. Zhang, C. D. Holmes, B. A. Schichtel,T. Blett, E. Porter, L. H. Pardo, and J. A. Lynch. 2013. Present and Future Nitrogen Deposition to National Parks in the United States: Critical Load Exceedances. Atmospheric Chemistry and Physics 13(2013):9083-9095.

Environ, 2015. Navajo Generating Station Visibility Assessment Protocol. National Environmental Policy Act, Environmental Impact Statement. Draft Protocol. September 2015.

Environ and Alpine. 2012. Western Regional Air Quality Modeling Study. Internet website: http://www.wrapair2.org/pdf/WestJumpAQMS_2008_Annual_WRF_Final_Report_February29_2012.pdf . Accessed May 24, 2016.

Lehn, R. 2015. Personal communication. Request for air quality monitoring data at KMC. From R. S. Lehn to S. Ellis. July 16, 2015.

Malm, W. C. 1999. Introduction to Visibility. Cooperative Institute for Research in the Atmosphere (CIRA). NPS Visibility Program, Colorado State University, Fort Collins, Colorado. Internet website: http://vista.cira.colostate.edu/improve/Education/intro_to_visibility.pdf. Accessed July 27, 2016.

McVehil-Monnett Associates, Inc. (MMA). 2016. Kayenta Mine Complex Air Quality Modeling Analyses. Final Report. January 2016. MMA Project Number 2574-13.

National Atmospheric Deposition Program (NADP). 2015a. NTN Data Access. Internet website: http://nadp.sws.uiuc.edu/data/sites/list/?net=NTN. Accessed May 24, 2016.

National Atmospheric Deposition Program (NADP). 2015b. CLAD U.S. Critical Loads of Sulfur and Nitrogen Access Database, version 2.5. Internet website: http://nadp.sws.uiuc.edu/committees/clad/db/. Accessed July 24, 2016.

Office of Surface Mining Reclamation and Enforcement (OSMRE) 2015. Final Environmental Impact Statement for the Four Corners Power Plant and Navajo Mine Energy Project, Navajo Nation, New Mexico. Internet website: http://www.wrcc.osmre.gov/initiatives/fourCorners/documentLibrary.shtm. Accessed July 27, 2016.

Office of Surface Mining Reclamation and Enforcement (OSMRE). 2011. Environmental Assessment: Kayenta Mine Permit (AZ-0001D) Renewal (Navajo County, Arizona). U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement (Western Region). August 2011. 185 pp + appendices.

Pardo, L. H. 2010. Approaches for Estimating Critical Loads of Nitrogen and Sulfur Deposition for Forest Ecosystems on U.S. Federal Lands. General Technical Report NRS-71. Newtown Square, Pennsylvania: U.S. Department of Agriculture Forest Service, Northern Research Station. 25 pp.

Ramboll Environ. 2016a. Photochemical Grid Modeling for Navajo Generating Station and Kayenta Mine Complex. Final Report. April 2016.

Ramboll Environ. 2016b. Near-field Air Dispersion and Deposition Modeling Report for Navajo Generating Station, National Environmental Policy Act Environmental Impact Statement and Endangered Species Act Compliance. Final Report. April 2016.

Ramboll Environ. 2016c. Near-Field Visibility Assessment for Navajo Generating Station and Kayenta Mine Complex. National Environmental Policy Act Environmental Impact Statement. Final Report. April 2016.

Ramboll Environ. 2016d. Navajo Generating Station Emissions Inventory, Draft Final Report. January 2016.

Ramboll Environ. 2016e. DRAFT FINAL NGS Near-Field Ecological Risk Assessment Environmental Impact Statement Final Report for the Navajo Generating Station. Version 2. March 2016.

Ramboll Environ. 2016f. Personal communication. Email from K. C. Heckel to B. Macdonald regarding OSMRE comment on far-field criteria pollutant impacts. July 19, 2016.

U.S. Environmental Protection Agency (USEPA). 2016. National Ambient Air Quality Standards Title 40 Code of Federal Regulations Part 50 (40 CFR 50).

U.S. Environmental Protection Agency (USEPA). 2015a. Average and Trends in Atmospheric Deposition at Clean Air Status and Trends Network Sites 1990-2013. Internet website: https://www.epa.gov/castnet. Accessed July 27, 2016.

U.S. Environmental Protection Agency (USEPA). 2015b. Technology Transfer Network Photochemical Modeling Tools. Internet website: https://www3.epa.gov/ttn/scram/photochemicalindex.htm. Accessed May 24, 2016.

U.S. Environmental Protection Agency (USEPA). 2014a. State and County Emission Summaries.. Internet website: http://www.epa.gov/air/emissions/where.htm. Accessed May 24, 2016.

U.S. Environmental Protection Agency (USEPA). 2014b. Air Data. Internet website: https://www3.epa.gov/airdata/. Accessed July 24, 2016.

U.S. Environmental Protection Agency (USEPA). 2014c. Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze. USEPA Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

U.S. Environmental Protection Agency (USEPA). 1995. Modeling Fugitive Dust Impacts from Surface Coal Mining Operations - Phase III, December 1995. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. Internet website: http://nepis.epa.gov/Exe/ZyNET.exe/2000DW9R.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1991+Thru+1994&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C91thru94%5CTxt%5C00000012%5C2000DW9R.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h

%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p%7Cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL. Accessed May 1, 2016.

Winges, K. and R. Steffel. 2016. Coal Dust from Rail Transport. Prepared for Navajo Generating Station Application Studies. Salt River Project Agricultural Improvement and Power District. Black Mesa and Lake Powell Railroad. January 2016.

Wyoming Department of Environmental Quality (WDEQ). 1979. Memorandum from C. A. Collins to R. Wood, Administrator. Fugitive Dust Emission Factors. January 24, 1979.

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Section 3.2

Climate and Climate Change

Acronyms and Abbreviations

ºC	degrees Celsius
ºF	degrees Fahrenheit
1969 Lease	Navajo Project Indenture of Lease
BART	Best Available Retrofit Technology
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BM&LP Railroad	Black Mesa & Lake Powell Railroad
BO	Biological Opinion
CAP	Central Arizona Project
CAWCD	Central Arizona Water Conservation District
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
Co-tenants	Salt River Project, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company
Development Fund	Lower Colorado River Basin Development Fund
EIS	Environmental Impact Statement
ERA	Ecological Risk Assessment
ESA	Endangered Species Act of 1973
GHG	Greenhouse Gas
HHRA	Human Health Risk Assessment
IPCC	Intergovernmental Panel on Climate Change
IWG	Interagency Working Group
km	kilometer
KMC	Proposed Kayenta Mine Complex
kV	kilovolt
kW	kilowatt
MW	megawatt
N-Aquifer	Navajo Aquifer
NEPA	National Environmental Policy Act of 1969, as amended
NGS	Navajo Generating Station
NGS Participants	U.S. (Reclamation), Salt River Project, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company
NHPA	National Historic Preservation Act
NNEPA	Navajo Nation Environmental Protection Agency
NO_2	nitrogen dioxide
NO_X	nitrogen oxide
OSMRE	Office of Surface Mining Reclamation and Enforcement

PFR	Partial Federal Replacement
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter of 10 microns or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 microns or less
PWCC	Peabody Western Coal Company
Reclamation	U.S. Bureau of Reclamation
ROW	Right-of-way
SCC	Social Cost of Carbon
SO_2	Sulfur dioxide
SRP	Salt River Project Agricultural Improvement and Power District
STS	Southern Transportation System
tpy	tons per year
USD	U.S. dollars
U.S.	United States
USEPA	U.S. Environmental Protection Agency
WTS	Western Transportation System

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3.2 Climate and Climate Change

3.2.1 Regulatory Framework

A changing climate poses challenges to the global social and economic structure as well as potential impacts on the natural environment. The accumulation of constituent atmospheric gases that inhibit the radiative cooling of the earth's surface are generally acknowledged to contribute to a changing climate both world-wide and on local or regional scales. These constituents are referred to as greenhouse gases (GHGs) in this document and in most references cited here.

A wide array of analyses and climate projections are underway to guide society and government agencies in understanding and addressing climate change, both to reduce the GHGs that are leading to a steady warming of the planet and to implement adaptations to the effects of climate change. The United States (U.S.) Council on Environmental Quality (CEQ) has identified climate change as an important consideration in the analysis of major federal actions that may affect climate and has issued draft and final guidance for addressing climate change in federal actions (CEQ 2016, 2014a).

This analysis relies extensively on the Intergovernmental Panel on Climate Change (IPCC), Fifth Assessment (IPCC 2014a,b,c, 2013), a four-volume set that addresses climate change, as a resource of existing environment and for predicting climate change during the period of the Proposed Action as well as the regional analyses provided by Garfin et al. (2013; IPCC 2014a).

The U.S. Bureau of Reclamation (Reclamation) has established its own Climate Adaptation Strategy (Reclamation 2014), which also is incorporated into this analysis. Reclamation's strategy recognizes that the weather and stream flow patterns that framed the development of the Western U.S. are changing, and that these changes affect the ability to deliver needed quantities of water and power to agricultural, Tribal, municipal, and industrial water users, as well as maintaining water for environmental flows and to support ecosystems. The goals of Reclamation's strategy are fourfold:

- Increase water management flexibility;
- Enhance climate adaptation planning;
- Improve infrastructure resiliency; and
- Expand information sharing.

The components of flexibility, planning, and resiliency are referenced in this section in terms of evaluating the Proposed Action and the relevant alternatives under consideration. This strategy also is aligned with the U.S. Department of Interior's Climate Adaptation Policy (U.S. Department of the Interior 2016), which calls on the Department's Bureaus to incorporate climate adaptation into agency decision making.

Executive Order 12866 on Regulatory Planning and Review, requires federal agencies, to the extent permitted by law, "…assess both the costs and the benefits of (an) intended regulation." Executive Order 13563 on Improving Regulation and Regulatory Review "reaffirms the principles, structures and definitions…established in Executive Order 12866…." Although this Environmental Impact Statement (EIS) does not address a proposed regulatory action, the federal Interagency Working Group (IWG) on Social Cost of Carbon (SCC) has asserted that SCC estimates can be useful in estimating the social benefits of reducing carbon dioxide emissions (IWG on SCC 2010). More recently, the Office of Management and Budget (2014) reiterated its conclusion that "…the SCC estimates provide valuable and critical insights for decisions makers and the public as they consider the costs and benefits of alternative policy choices….."

The CEQ's National Environmental Policy Act (NEPA) Revised Draft Greenhouse Gas Guidance notes that "…although developed specifically for regulatory impact analyses, federal SCC, which multiple federal agencies have developed and used to assess the costs and benefits of alternatives in rulemakings, offers a harmonized, interagency metric that can provide decision makers and the public with some context for meaningful NEPA review. When using the federal SCC, the agency should disclose the fact that these estimates vary over time, are associated with different discount rates and risks, and are intended to be updated as scientific and economic understanding improves" (CEQ 2014a).

The final CEQ guidance (CEQ 2016) states that "when an agency determines that a monetized assessment of the impacts of greenhouse gas emissions or a monetary cost-benefit analysis is appropriate and relevant to the choice among different alternatives being considered, such analysis may be incorporated by reference or appended to the NEPA document as an aid in evaluating the environmental consequences." For this EIS, the greenhouse gas emission rate is an important differentiating factor among alternatives. When an EIS addresses economic benefits of an action, it is helpful to also disclose potential costs. The estimated Social Cost of Carbon presented later in this section is a proxy measure for such costs as related to climate change, providing a means for comparing the alternatives.

The final CEQ guidance states that the EIS should provide the decision-maker and the public with a recognizable frame of reference for comparing alternatives and mitigation measures. Section 1.8 provides an overview of the USEPA Clean Power Plan published in October 2015. The Clean Power Plan would establish carbon emission performance limits for various state and tribal jurisdictions. The effect of the Clean Power Plan on future operations at NGS is currently unknown, pending resolution of legal challenges to the rule, as well as a final determination regarding implementation of the Clean Power Plan on Navajo Nation lands. If or when the Clean Power Plan is implemented, it would provide a framework for evaluating future reductions in greenhouse gases at NGS that have been estimated under the various alternatives in this EIS.

Emissions of carbon dioxide (CO_2) and other GHGs (methane and nitrous oxide) are recognized as change agents contributing to global climate change. A wide range of effects to the human and natural environments are anticipated in conjunction with rising temperatures. Many of those effects involve externalities, that is, effects to resources and populations that are not reflected in market transactions and for which economic values are not established or recognized. Rising sea levels and potential damages to physical infrastructure, economies, and social disruption in coastal areas associated with such rises are examples of these externalities. Increased recognition and consideration of externalities is an important element of the ongoing analysis of climate change policy in the past several decades (CEQ 2014b; IPCC 2014c; National Science and Technology Committee 2008).

3.2.2 Study Areas

3.2.2.1 Proposed Action and Action Alternatives

The study area for characterizing climate covers southern Utah and Northeastern Arizona. This area includes an assessment of current conditions as well as the current changes or trends in climate conditions being observed. As climate changes in the region the Proposed Action may affect or be affected by the changing climate. Conditions and trends in a regional study area that includes the Proposed Action would form a pattern relevant to the evaluation of the projected change and its environmental consequences on resources being affected by climate change as well as how climate change could affect the design and operation of the Proposed Action. This study area includes the region that supplies water to Lake Powell because the Proposed Action and action alternatives would be affected by the availability of Colorado River water flow.

3.2.2.2 Localized Effects of Climate Change on Socioeconomic Conditions

All project components are located in the U.S. Southwest. The current state of the practice for climate change assessment does not extend to specific locations. Consequently, the long-term outlook for climate change conditions for the U.S. Southwest were used to provide a broad framework consideration of potential impacts from climate change on socioeconomic conditions in northeastern and central Arizona. The primary study area for localized effects of climate change on socioeconomic conditions includes the Navajo Nation, Hopi Reservation, and northern Coconino and Navajo counties, Arizona, with a focus on the Navajo chapters and portions of the Hopi Reservation surrounding the Navajo Generating Station (NGS) and proposed Kayenta Mine Complex (KMC) as well as the nearby off-reservation communities in the two counties, particularly Page. A secondary study area includes the transmission line corridors, communications sites and the portions of central and southern Arizona that encompass the service area for the Central Arizona Project (CAP).

The transmission system and communication sites include portions of three Indian Reservations and five counties in Arizona, Utah, and Nevada. A key concern would be the frequency and severity of extreme weather events and wildfires, which have the potential to disrupt service, damage the transmission lines and communication sites, and require additional maintenance or reconstruction.

3.2.3 Affected Environment

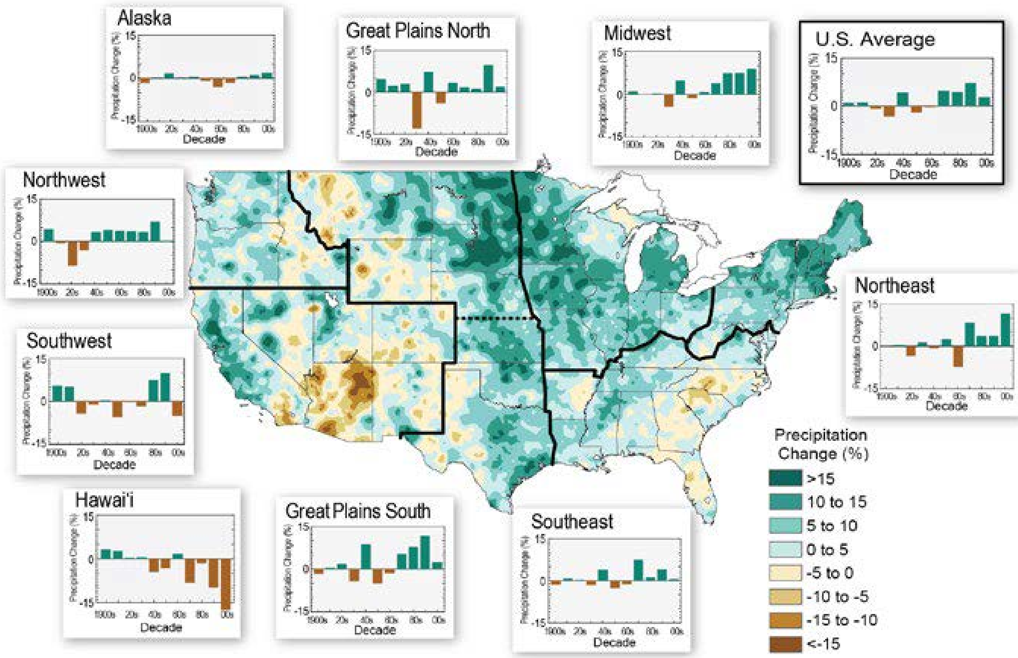
3.2.3.1 Navajo Generating Station

3.2.3.1.1 Global and Regional Temperatures and Precipitation

Globally, atmospheric surface temperatures have risen steadily for the past several decades (IPCC 2013). Regional temperature patterns over North America are affected by an array of large-scale atmospheric phenomena and cycles that may affect temperatures differently in various locations and during the separate seasons. These cycles lead to persistent weather patterns that vary substantially from year-to-year and include extended periods (i.e., including years) of temperatures that are above or below average. A general surface warming over North America has been documented since 1900, and particularly in the U.S. Southwest since 1981 (IPCC 2013). Figure 2.22 in IPCC (2013) indicates that the U.S. Southwest has shown some substantial warming over the 20th Century, estimated at approximately 2°F in Northern Arizona.

The Assessment of Climate Change in the Southwest U.S. (Hoerling et al*.* 2013) summarizes a broad increase in temperatures over the six-state U.S. Southwest. The average daily maximum temperature increased by 1.4°F from the 1901 to 2000 average to the 2001 to 2010 10-year average. It is notable that the average daily minimum temperature for the same comparison increased by 2.2°F, and this increase was strongest in the latter half of the period. Hoerling et al. (2013) also observed fewer cold waves and more heatwaves over the U.S. Southwest during 2001 to 2010 than during the previous century.

The overall regional precipitation trends are less clear than the regional depictions of temperature changes. Over the globe as a whole, when virtually all the land area is taken into consideration, the resulting time series shows little change in land-based precipitation since 1901 (IPCC 2013). While the total moisture levels in the atmosphere have increased, the relative humidity has decreased primarily due to the concurrent increase in temperature. The IPCC panel assessment indicates low confidence in determining a trend in precipitation that is associated with the changing climate. However, the National Climate Assessment (Walsh et al*.* 2014) shows a 10 percent to 15 percent reduction in local precipitation over northeastern Arizona when comparing the 1991 to 2012 annual average to the 1901 to 1960 annual average. **Figure 3.2-1** from Peterson et al. (2013) shows a pattern of reduced precipitation over northeastern Arizona. This reduction is unique in that it is the most dramatic reduction in total annual average precipitation across the continental U.S. as well as the U.S. Southwest.



Source: Peterson et al. 2013.

Note: The colors on the map show annual total precipitation changes for 1991 to 2012 compared to the 1901 to 1960 average, and show wetter conditions in most areas. The bars on the graphs show average precipitation differences by decade for 1901 to 2012 (relative to the 1901 to 1960 average) for each region. The far right bar in each graph is for 2001 to 2012.

Figure 3.2-1 National Precipitation Trends

3.2.3.1.1.1 Colorado River Runoff

Figure 3.2-2 provides a history of Colorado River flow at five streams that feed into Lake Powell (Reclamation 2005). The figure shows a long-term drop in river flows, with considerable interannual variability. A separate analysis concluded that the water flow at Lees Ferry is representative of the annual water flow into Lake Powell above the Glen Canyon Dam. See data and analyses in **Appendix 3.2-A**, Exhibit 1.

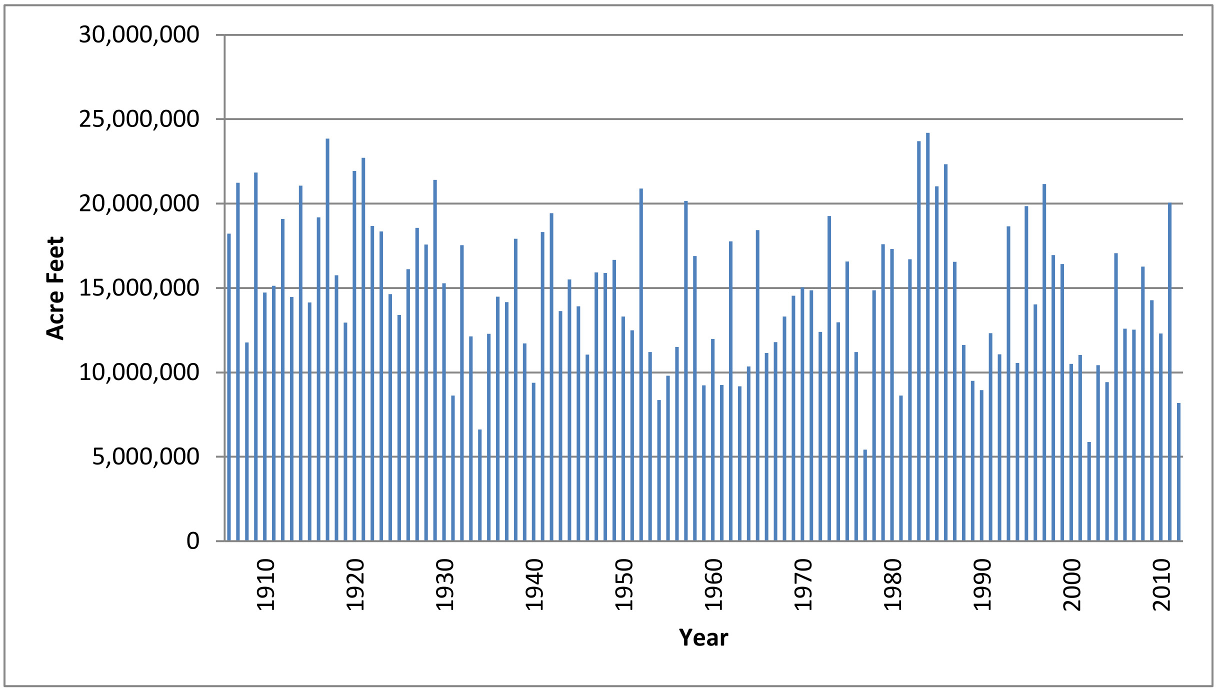


Figure 3.2-2 Total Annual Flow in Streams that Feed Lake Powell

Statistical analysis of the individual yearly runoff data depicts an average (linear slope) decrease of approximately 33,000 acre-feet per year over the period from 1906 to 2012, with the linearized runoff level at 16.67 million acre-feet in 1906 and 13.11 million acre-feet in 2012. While the linear estimate cannot be used to predict any one year's total runoff, the long-term trend in the data is a basis for characterizing the total decline in runoff during that period.

3.2.3.1.1.2 Growing Season

Cayan et al. (2013) depict the climatological freeze-free season throughout the U.S. Southwest. Over northeastern Arizona, the length of that season varies from about 150 to 200 days (Cayan et al. 2013). Hoerling et al. (2013) also point out that the growing season in the U.S. Southwest increased approximately 17 days from 2001 to 2010 compared to the average growing season length in the 20th Century.

3.2.3.1.2 Temperature and Precipitation at Regional Sites

The climate of the Proposed Action study area was assessed by examining climatological parameters collected and maintained by the Western Regional Climate Center (2014). Summaries have been provided for nearby sources with extensive records. Although some of the station monitoring programs have been discontinued, the available data have been provided as a reference and a general depiction of regional temperatures, precipitation, and snowfall.

The local climatological conditions were determined by examining the meteorological record at separate sites, including Pinon, Kayenta, and Page, Arizona. These sites span the region and include a representation of elevation within the region. The seasonal pattern is clearly dominant with the highest seasonal average temperatures in July and early August and the lowest seasonal temperatures in December and January. Average wintertime low temperatures are in the teens, but the data record shows a number of very low temperature extremes near negative 20 degrees Fahrenheit (-20°F) at the higher elevation sites.

Precipitation patterns also are represented by the record at each of these sites as well as at Betatakin and Canyon de Chelly. **Figure 3.2-3** depicts the average monthly total precipitation for the five stations for each month of the year. Detailed precipitation data for these sites are provided in **Appendix 3.2-B**, Exhibit 1. The pattern shows a consistent seasonal feature, including the maximum precipitation in July to October at all sites. This precipitation/weather pattern is referred to as the Southwest Monsoon, which brings critical rainfall to support crop production as well as support for the native vegetation and pastures. The monsoon feature is strongest at the sites with higher elevations. Winter precipitation can occur as rain or snow and results from the passage of mid-latitude storm systems from west to east during that season. Annual average precipitation ranges from 6.44 inches at Page, to 7.66 inches at Kayenta, 8.88 inches at Pinon, 9.14 inches at Canyon de Chelly, and to 11.94 inches at Betatakin.

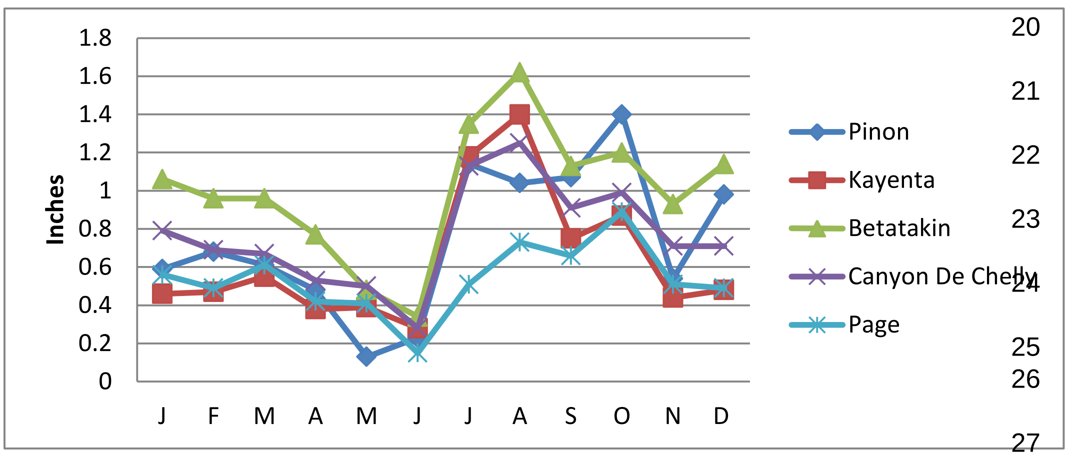


Figure 3.2-3 Average Monthly Total Precipitation

Snowfall also is a climatic feature for winter months, and generally is higher at higher elevations. The monthly average total snowfall for these same five sites is shown in **Figure 3.2-4**. Snow falls from November through April and is greatest at Betatakin and least at Page.

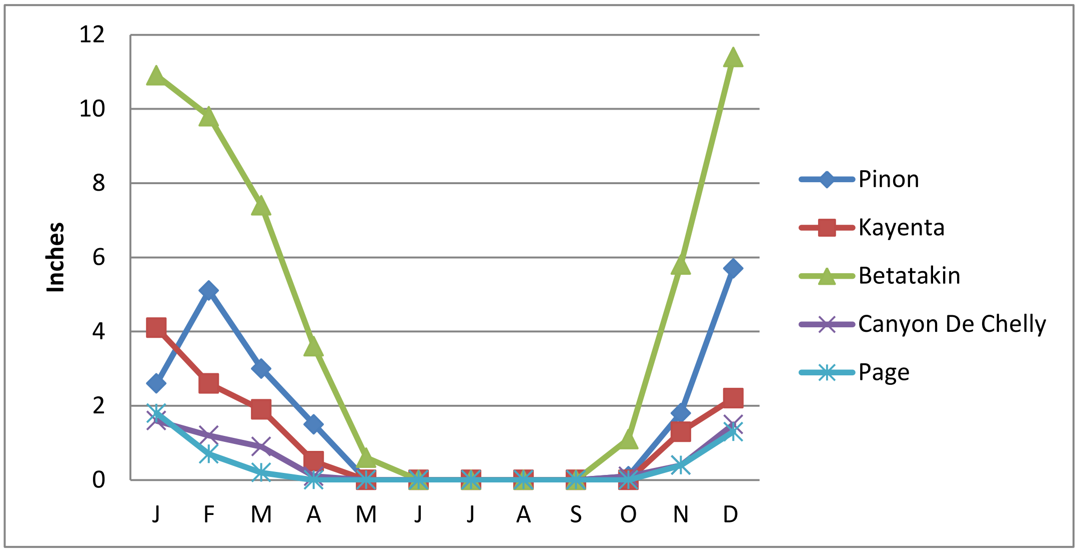


Figure 3.2-4 Average Monthly Total Snowfall

Figure 3.2-5 depicts the distribution of yearly total precipitation at two sites, including Betatakin and Canyon de Chelly. The data are categorized by ranges of total annual precipitation in inches) and represents the number of years in each precipitation category. There are a substantial number of wet and dry years at both sites, but most years are below average at Canyon de Chelly, while the annual pattern is more broadly distributed and generally has greater precipitation at Betatakin near the Black Mesa.

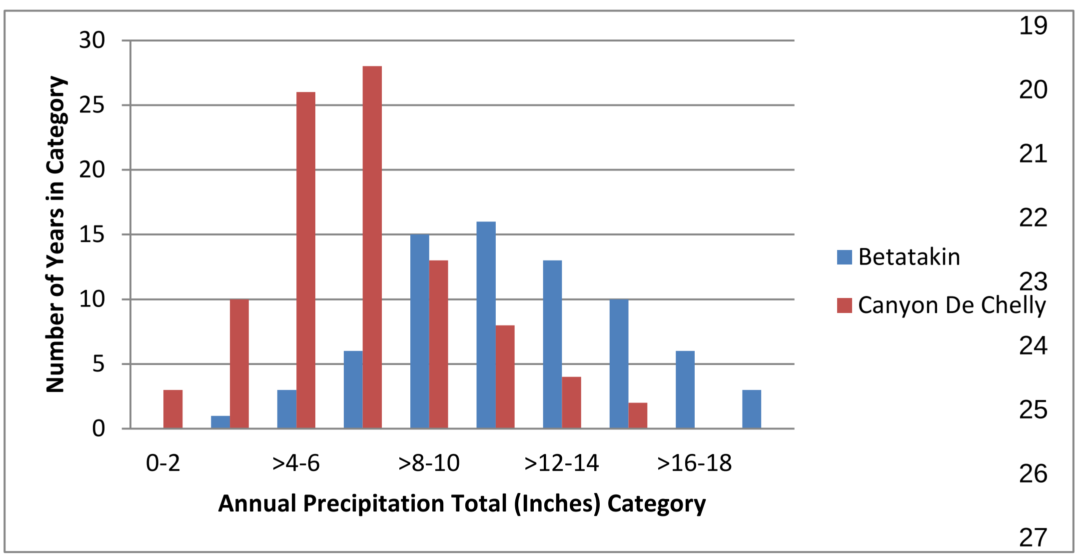


Figure 3.2-5 Distribution of Annual Precipitation Totals for Betatakin (73-year record) and Canyon de Chelly (91 year record)

Overall, climatic conditions in this region exhibit a great deal of variability, both daily and annually. Temperature and precipitation patterns also are greatly affected by elevation in this region.

3.2.3.1.3 Regional Climate Trends

The evaluation of climate change as part of this NEPA analysis includes characterization of climate change as part of the existing environment, and characterization of climate change that is reasonably foreseeable during the period of the Proposed Action. The reviews summarized below cover the physical basis of climate change and climate change related to ecosystem water resources, and the human environment, including agriculture and socioeconomics. For each of these components, the analysis provides: a description of global and regional climate as the existing environment; the effect of the Proposed Action; and the cumulative effect of the Proposed Action, including projected changes in climate for the duration of the Proposed Action.

The review of climate change addresses the unique character of the region. There are three distinct climates within the Navajo Nation and Hopi Reservation: the cold humid climate of the heights; the steppe climate of the mesas and the high plains; and the comparatively warm desert, including the lower portions of the Chaco and Chinle Valleys and all of the southern, western, and northwestern parts of the Navajo Nation. Eight percent of the area is classified as humid, 37 percent as steppe, and 55 percent as desert.

Each of these zones has a distinctive climate (Navajo Ways in Government 1963).

- The humid zone temperatures average from 43°F to 50°F with a low of 4°F and a high of 80°F. The annual rainfall is from 16 to 27 inches and the growing season averages 95 days.
- The steppe zone annual average temperature ranges from 45°F to 50°F with a low of 10°F and a high of 88°F. Annual rainfall is from 12 to 16 inches and the growing season averages 147 days.
- The desert-zone temperatures average 50°F to 60°F with a low of 11°F and a high of 110°F. Annual rainfall is between 7 and 11 inches and the growing season averages 173 days.

A spatial depiction of the average change in temperature in this region is provided by The Third National Climate Assessment (Walsh et al. 2014), which shows the increase in temperature for the 1991 to 2012 period compared to the 1901 to 1960 period was between 1.0°F and 1.5°F over the Navajo Nation and Hopi Tribal area, but greater than 1.5°F over most of Arizona and southern Utah.

As an example of the local patterns, reflected in three stations in the region (Western Regional Climate Center 2014) with a long-term record, **Figure 3.2-6** shows the past change in annual average temperatures at these locations. Detailed temperature data are provided in **Appendix 3.2-B** Exhibit 2. The data show a continual increase in average temperature, masked with considerable variability. Years with insufficient record are not included in this depiction. The average annual temperature at Canyon de Chelly increases by approximately 0.07°F per year, on a linear average, which is negligible compared to the year-to-year variability. Monthly data show a steady increase in average July monthly minimum temperatures. Data for January show that prior to 1940 there were occasional months with very low average minimum January temperatures below 0°F; however, none of the average January minimum temperatures have been below 10°F since 1980. This pattern implies that some occasional extremely cold months that occurred in the early half of the 20th Century no longer occur in the region, consistent with the consensus provided by Hoerling et al. (2013). The temperature data for Betatakin and Page show a less dramatic trend and cover a shorter period. These differences expose the variability of trends in temperature that exist over the region.

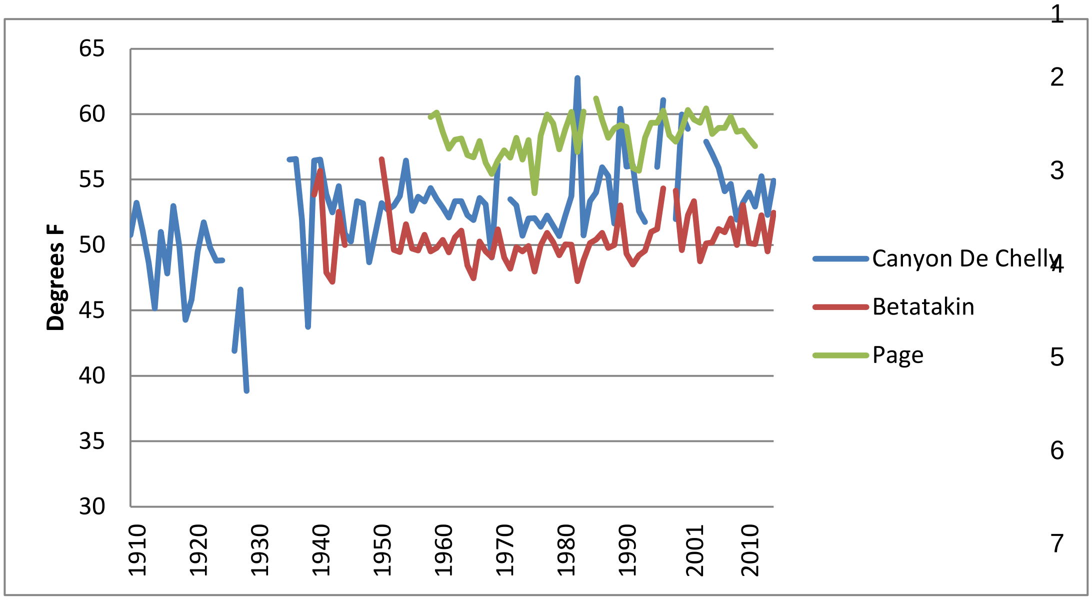


Figure 3.2-6 Average Annual Temperature

The long-term temperature changes at Canyon de Chelly indicate a relatively steady increase in average daily temperatures, but with a substantial variability in data from year-to-year.

3.2.3.1.3.1 North American Monsoon

The annual local/regional precipitation pattern is dominated by the North American Monsoon, with clearly evident mid-late summer peaks, as depicted in **Figure 3.2-7** for Canyon de Chelly. Detailed data for Canyon de Chelly precipitation are provided in **Appendix 3.2-B**, Exhibit 3. This monsoon climatic feature dominates the weather patterns in late summer, and brings a steady flow of moisture from the southwest over Arizona, the Black Mesa, and the Four Corners Region in general. The annual or seasonal pattern of precipitation in the region exhibits a monthly bimodal distribution, with wintertime rain and snow providing a slight peak, and the Rocky Mountain Monsoon, or North American Monsoon providing a dominant annual peak in mid- to late-summer (July-August). The wintertime precipitation develops as part of a global shift in the storm tracks or jet stream southward during the colder months. Precipitation associated with the passing storms can be highly variable both within individual storms but also from year-to-year.

The monthly precipitation exhibits a wide range of variability from year to year at locations in northeastern Arizona, including the Navajo Nation, for which the data from Canyon de Chelly is used to depict the range and standard deviation. As can be deduced from **Figure 3.2-7**, the mean seasonal peaks in precipitation are evident along with a wide range of inter-annual variability, with monthly standard deviations in total precipitation approximately equal to the mean values. The precipitation for each month has at least 1 year with no measured precipitation, while the maximum individual monthly totals can be 3 to 5 times the monthly mean.

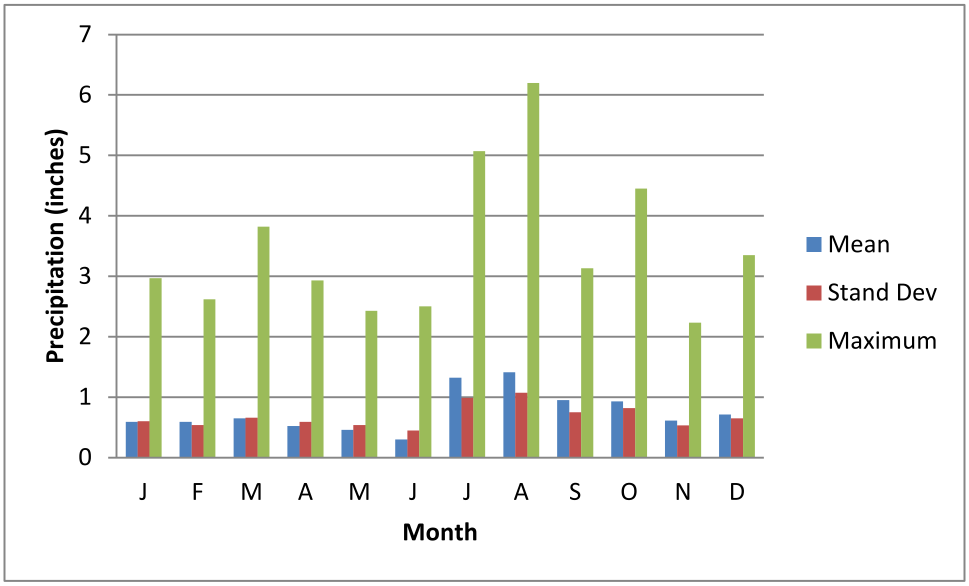


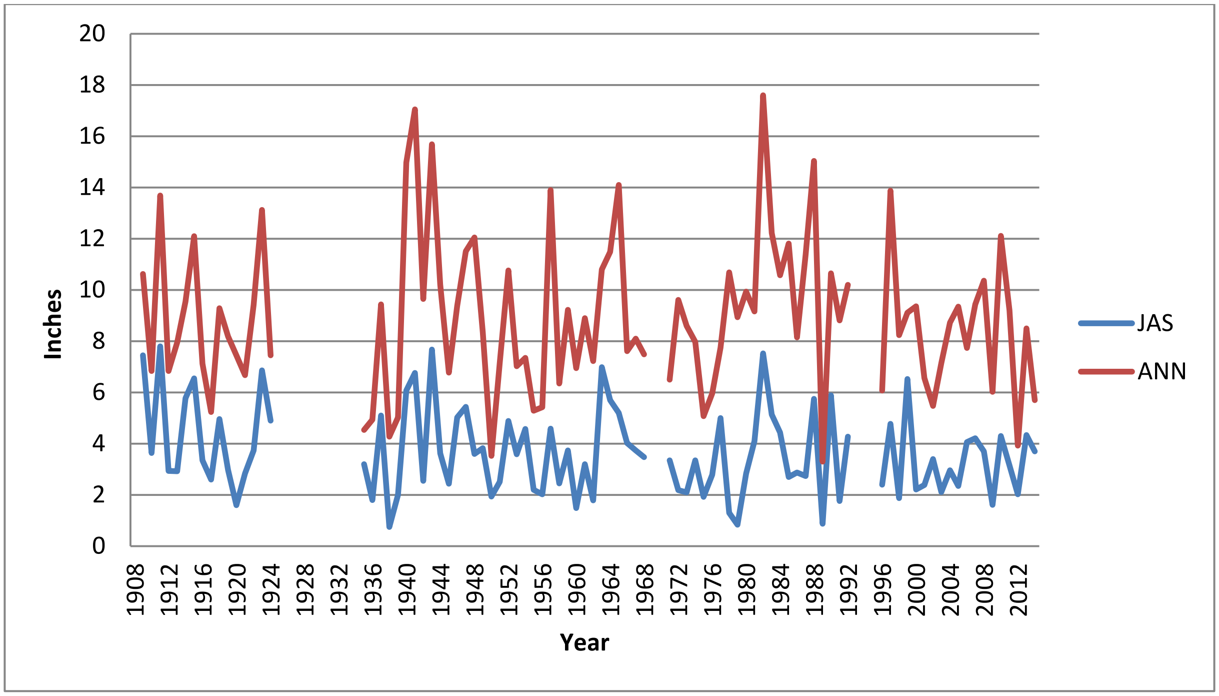
Figure 3.2-7 Monthly Total Precipitation Statistics at Canyon de Chelly from 1909 to 2014

In the North American Monsoon System, no distinct changes in precipitation patterns have been observed over the last half of the 20th Century (Anderson et al. 2010), but a positive trend in precipitation has been detected in northern Arizona and western New Mexico. There has been a systematic delay in monsoon onset, peak period, and termination (Grantz et al. 2007). Locally, precipitation patterns at Canyon de Chelly show a slight reduction in total precipitation both on an annual basis and for the regular monsoon season (July, August, and September), as shown in **Figure 3.2-8**. This figure also shows that the relatively high peaks that occurred regularly in the 20th Century have not been recorded since the mid-1990s.

3.2.3.1.3.2 Water Supply

Climate change can affect many activities that rely on a steady supply of surface water, and can have an effect on recharge of groundwater as well. Many studies have addressed these issues, particularly in arid and semi-arid regions such as the U.S. Southwest. This water supply analysis primarily relies on a summary that has been prepared for the National Climate Assessment (Udall 2013).

Water supply in this region is dependent on two separate factors: supply through direct precipitation and supply through runoff collected in the river basins, specifically the Colorado River, for delivery to regional users. While there are relationships in these two features, the nature of the changes in water supply related to climate change are distinctly different. Generally with the increased temperature, leading to increased evaporation, the water demands for any outdoor use, such as agriculture and surface watering, would increase. The higher temperatures also would lead to increased evapotranspiration from plants, and the longer growing season would increase water demand.



Note: ANN = observed annually; JAS = monsoon season July, August, and September.

Figure 3.2-8 Observed Annual and Monsoon Season Total Precipitation at Canyon de Chelly

Surface water quantity also is affected by climate change and is sensitive to changes in temperature and patterns of precipitation. The recent record of precipitation patterns and runoff patterns demonstrates that the existing water supply environment is changing in response to climate change. These current changes are highlighted in this section.

On the Navajo Nation, decreasing snowfall, increasing temperatures, and declining streamflow has been observed from 1996 to the current period (Redsteer et al. 2010). Anecdotal evidence shows that stream flows along with springs and other surface water features has changed substantially during the last century. Some historic ephemeral streams have experienced no flow during spring run-off and summer rains in recent years (Redsteer et al*.* 2013).

One of the key elements of water supply and water quality is the recharge of aquifers from annual rainfall. On the Black Mesa, the N-Aquifer is an important water resource that is recharged seasonally from precipitation in the highlands, principally during the winter and spring (Zhu and Kipfer 2010). The Shonto area in the northwestern corner of the mesa, accounts for approximately one-third of the total recharge in the basin and most of the water that flows into the center of the basin (Cooley et al. 1969).

While anecdotal evidence indicates that there have been reduced stream flows on the Navajo Nation lands, direct formal long-term records are not available. One reliable long-term record would be the annual river flows from the San Juan River measured at Bluff, Utah. Upstream of this site, the San Juan River drains a large portion of the Navajo Nation and would be representative of long-term changes in surface water flows, largely in response to local precipitation and spring runoff of mountain precipitation. **Figure 3.2-9** depicts the total annual San Juan River flow at Bluff, Utah. Detailed data are provided in **Appendix 3.2-B**, Exhibit 1.

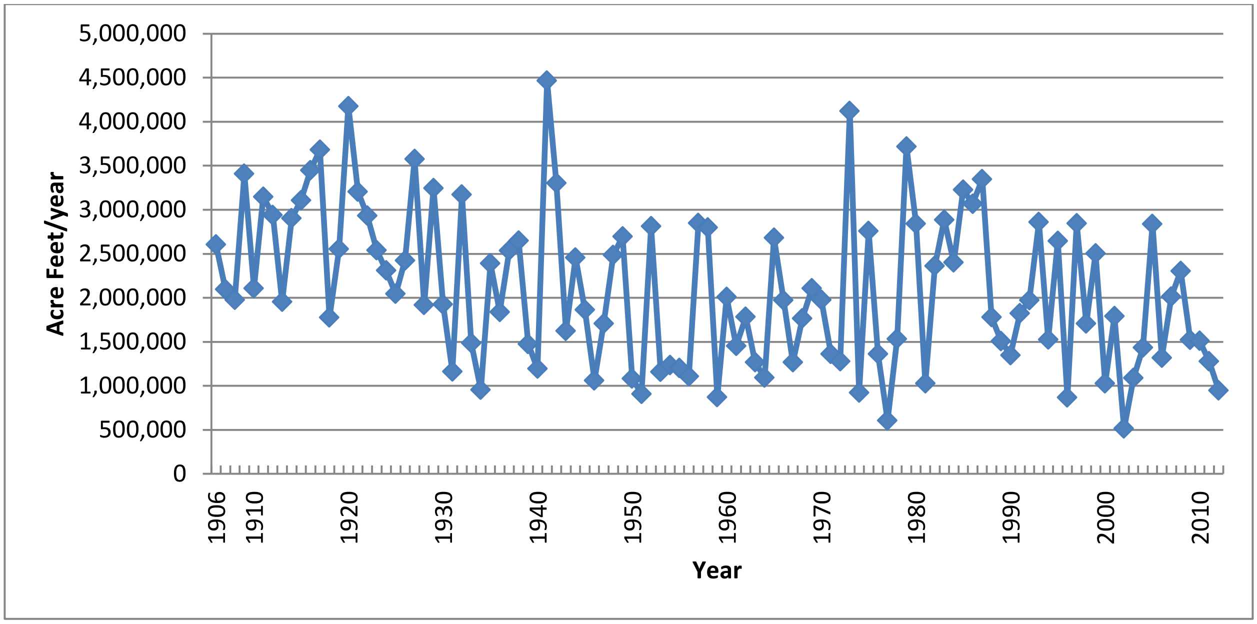


Figure 3.2-9 Total Annual San Juan River Flow at Bluff, Utah

Analysis of the Bluff data indicates an annual reduction of approximately 9,200 acre-feet per year as a long-term linearized trend. This pattern is somewhat consistent with the data for the Colorado River Basin, discussed above; however, the reduction as a percent of the annual total is double that of the Colorado River (0.44 percent per year, versus 0.22 percent per year for the Colorado River) and reflects individual periods with declining flows (1920-1935 and after 1990). Although the year-to-year variability is substantial, the ongoing reduction in river flows at this site is clear. Individual yearly data are provided in **Appendix 3.2-A.**

Seasonal Snowmelt Runoff

As noted above, the annual total seasonal snowmelt and runoff in the Colorado River above Lake Powell, has been decreasing over the past century, but also has experienced a wide range of inter-annual variability. Data from Reclamation (2012) indicate that the gap between supply and use of Colorado River water has narrowed over the 20th Century, and the demand in recent years has exceeded the supply. The observed change in snowmelt, with earlier melting and peak runoff, has contributed to lower total water supply from this resource.

Seasonal Rainfall Patterns

The Southwest Monsoon precipitation pattern also has shown high year-to-year variability. A review of the monsoon precipitation in Tucson and Phoenix supports a conclusion that, precipitation (during the Monsoon season, as measured in southern Arizona) has neither generally increased nor decreased since 1895 (Guido 2009). However, the linear least-squares trend in data for Canyon de Chelly shows a decrease in total precipitation for July, August, and September of approximately 0.01 inch per year, meaning that the total Southwest Monsoon precipitation average at this site, is approximately 1 inch less than at the start of the 20th Century; however, this rate of decline is negligible compared to the year-to-year variability.

3.2.4 Environmental Consequences

3.2.4.1 Issues

3.2.4.1.1 Greenhouse Gases in the Atmosphere

GHGs in the atmosphere absorb the infrared radiation from the earth's surface and re-radiate that energy into the atmosphere and back to earth. GHGs include water vapor as a major, but locally variable, constituent along with seven basic compounds or groups that are well-mixed and not sensitive to local concentrations: 1) CO_2, 2) methane, 3) nitrous oxide, 4) hydrofluorocarbons, 5) perfluorocarbons, 6) sulfur hexafluoride, and 7) nitrogen trifluoride. Of these gases, only the first three are released by the NGS and proposed KMC operations and are relevant to depicting the existing environment for the Proposed Action. The data show the steady increase in the concentrations of these gases since the end of the 18th Century. Global GHG emissions from fossil fuel combustion and cement production was estimated to be approximately 35 billion metric tons in 2011 (IPCC 2013).

The trend and changes in atmospheric concentration and emission rates for these three compounds are the basis for evaluating the Proposed Action relative to climate change. GHGs are evaluated in terms of their global warming potential based on their CO_2-equivalent (CO_2e) effect on trapping infrared radiation in the atmosphere. CO_2e is calculated to represent the combined effect of a combination of GHGs using the concentration of each GHG multiplied by that gas' global warming potential, and calculating the sum of those multiples. The global warming potential for CO_2 is set at 1 as a comparative value. The mass-weighted global warming potential of methane is now set at 25 (i.e., one pound of methane emitted into the atmosphere has the same global warming potential as 25 pounds of CO_2, under this system), and the mass-weighted global warming potential of nitrous oxide is set at 295. Sulfur hexafluoride is a very powerful GHG and may be released by leaks from electricity distribution systems, but those effects were not evaluated as part of this analysis because none of the alternatives would make any substantial change in the electricity distribution system.

In the U.S., total emissions of GHG are estimated at 6,742 million metric tons of CO_2e (U.S. Environmental Protection Agency 2015). The peak U.S. emission rate was 7,450 million metric tons in 2007, with a reduction in 2013 of almost 10 percent from the peak year. Fossil fuel combustion accounted for 5,196 metric tons in 2013, or approximately 77 percent of the U.S. total GHG emissions for that year.

3.2.4.1.2 Air Quality

Air quality conditions have been improving over the recent decades, including in the U.S. Southwest; however some of the most adverse air quality conditions persist in the major urban areas (e.g., Los Angeles, Phoenix). As noted in Section 3.1.3, trends in air quality improvement have been noted in the region of the Proposed Action, and it is not certain if the changing climate at this time is contributing to impacts on human health or the environment because emission controls and other reductions in pollutant emitting sources have offset the effect of climate change.

3.2.4.1.3 Water Resources

Climate shifts, involving several centuries of wet or dry periods, have been documented in the U.S. Southwest by numerous investigations (e.g., Thornthwaite et al. 1942; Cook et al. 2004; Karlstrom 1988). In northeastern Arizona, the current drought cycle generally is thought to have begun in the mid-1990s (Redsteer et al. 2010). As described in Section 3.2.3, over the next several decades the regional effects of climate change are anticipated to include temperature increases (with considerable local variability), an increasing growing season length, and declining runoff volumes in the Colorado River Basin overall. Runoff declines are being exhibited currently in the study area.

As described in Section 3.7 (Water Resources), there typically are two peak periods for runoff: early spring and the late summer monsoon. Monsoonal moisture plays a major role in study region hydrology.

As mentioned earlier in this section, some investigations conclude that there are no precipitation trends in the North American Monsoon. Others indicate a positive precipitation trend (more rainfall) in in northern Arizona and western New Mexico, with a systematic delay in monsoon onset, peak period, and termination. As discussed in Section 3.2.3, local precipitation patterns at Canyon de Chelly show a slight reduction in total precipitation, both on an annual basis and for the regular monsoon season (July, August, and September) as shown in **Figure 3.2-8**. These variations are typical of local and regional precipitation conditions throughout the water resources study area, and lead to uncertainties regarding climate change and related water resources impacts. These primarily include (Reclamation 2016):

- Spatially downscaling climate model outputs from global scales to basin scales;
- Subsequently characterizing hydrologic responses in specific regions or basins to projected climatic changes, and;
- Definitively attributing individual hydrologic events (e.g., floods or droughts) at a particular place and time to the effects of climate change.

Water resources study areas for the project overlap the boundary between the Upper and Lower Colorado River basins (Reclamation 2016). Broadly regional climatic findings that apply to the impact assessment include (Reclamation 2016):

- Temperature increases are anticipated across the basin, with the largest changes in spring and summer. (This also will lengthen the growing season.);
- Springtime precipitation is expected to decline throughout the Colorado River Basin. Drying conditions also are projected during summer, although monsoon influences may create slight increases in precipitation for some areas of the Lower Basin;
- Streamflow changes (both surface runoff and channel baseflow components) will be diverse, but declines are generally expected; and
- Droughts lasting five or more years are projected to occur 50 percent of the time over the next 50 years.

Based on these factors, anticipated climate change impacts to deep aquifers in the study area (i.e., the D- and N-Aquifers) would be a gradual lowering of the piezometric surfaces in both aquifers due to reduced recharge. These impacts would be negligible through the year 2044 as well as over the subsequent period to 2110, which is included in groundwater modeling for the project. Groundwater analysis (Leake et al. 2016) estimates regional mean annual recharge for the N-Aquifer in the range of approximately 12,200 to 13,900 acre-feet per year (Water Resources **Appendix WR-10**). Mean annual recharge estimates for the D-Aquifer are approximately 5,400 acre-feet per year.

The reduction in regional mean annual recharge to these aquifers from climate change is uncertain due to the uncertainties identified above. Groundwater modeling simulations for the N-Aquifer suggest that it takes thousands of years for water levels to fully respond to recharge changes (Zhu et al. 1998). Ancient ice-age recharge rates (i.e., over 11,000 years ago) have been estimated to be two to three times higher than current rates; however, between 6,000 to 11,000 years ago, estimated recharge was about half what it is today (Zhu et al. 1998). On this basis, the N-Aquifer has undergone substantial past changes in recharge, but in timeframes of thousands of years. Over most of the study area, it would take much more time than is relevant to this project for climate change effects on N-Aquifer or D-Aquifer water levels to be evident. Because of this, climate change effects on D- or N-Aquifer water levels would be negligible over most of the study area. Similarly, changes to D- or N-Aquifer spring discharges or stream baseflows also would be negligible over most of the study area. One locale that could be an exception is the area around Shonto Wash and Tsegi Canyon. Much of the study area recharge occurs in this locale, and connected local discharge features (i.e., springs and stream baseflows) may decline over decades if warmer and drier conditions persist.

Shallower groundwater aquifers, including those in the Wepo and Toreva formations and streamlain alluvial deposits, are already exhibiting declines from drought over the past 20 years or so. These resources as well as related springs and seeps would undergo more pronounced impacts from anticipated future climate change. These aquifers are at or near the land surface over much of Black Mesa. On the mesa, local precipitation and drainage conditions have far greater influence over water levels in these aquifers than in the D- or N-Aquifers. If less precipitation continues to occur annually or seasonally, recharge to these aquifers would decline. These shallower zones support more extensive vegetation in canyons and washes, and that vegetation withdraws groundwater by transpiration. Warmer temperatures and a longer growing season would generate greater transpiration uptake by vegetation. As a result of these climate changes, water levels in these shallower aquifers would decline over decades, which would reduce associated spring flows and stream baseflows from the Wepo and Toreva formations or from connected stream alluvium and encourage the extent of deeper-rooted vegetation such as tamarisk. These impacts could lead to changes in biological habitats.

With respect to surface water resources, climate changes would reduce stream runoff and the amount of water retained in ponds and impoundments. Overall, lower precipitation rates would reduce rainfall runoff or snowmelt from the higher elevations. This would combine with greater temperatures and evaporation to reduce water levels and inundated areas in local ponds and impoundments as well as in Lake Powell. In small retention structures, evaporation would reduce the quality of water retained over long periods by removing water while leaving dissolved constituents behind. Over time, this would increase the concentrations of total dissolved solids and other constituents in these impoundments. Changes in the precipitation regime, such as lower overall precipitation but possibly more intense low-frequency storms, would interact with grazing and vegetation shifts to change erosion and sediment yield as well as the storage and transport of sediment through stream networks. These impacts would create additional instabilities in and near alluvial streams and river channels.

The responses of regional drainage systems to climate change are not well understood, particularly with respect to arroyos in alluvial valleys on the Colorado Plateau (Webb and Hereford 2001). A number of causes and effects are theorized in regional research. These primarily involve land use changes (particularly grazing), geomorphic processes that vary in time and space within individual drainages, and climate change responses. Arroyo downcutting on Black Mesa has been attributed to drought (Karlstrom 1988). In contrast, arroyo infilling across the region also has been attributed to drought (Hereford 2016). Most currently accepted theories emphasize climatic conditions as major factors for arroyo filling and cutting. Less emphasis is placed on grazing as a factor, due to stratigraphic studies that indicate ancient cycles of arroyo change centuries before European settlement.

Hereford (1989) suggests that reduced warm-season rainfall (June 15 through October 15) from the early 1940s through the 1970s contributed to sediment storage and floodplain development in Colorado River tributary channels. A reduction in the number of large floods during this drier period is believed to have contributed to this. Hereford et al. (2014) also found that the recent wet episode of the late 1970s to mid-1990s generated gully erosion of recent alluvial terraces in the nearby Grand Canyon. A suggested cause is that during intervening wet episodes, increased precipitation intensity generated greater runoff and fluvial erosion across a wide range of spatial scales (Hereford et al. 2014). Some of these impacts depend on El Niño Southern Oscillation intensity and frequency; Arizona typically has greater flood frequency during warm El Niño Southern Oscillation conditions (i.e., El Niño) (Webb and Hereford 2001). If the “ongoing Early 21st Century Drought beginning in the mid- to late 1990s” (Hereford et al. 2014) continues or intensifies, then arroyo infilling and floodplain formation likely would be encouraged by climate change across the study area. This could narrow the alluvial stream channels and provide opportunities for more extensive adapted vegetation.

3.2.4.1.4 Biological Resources Related to Climate Change

Climatic variation in the U.S. Southwest, as in any region, also is reflected by variations in land cover and land use (Section 3.14). Within the U.S. Southwest, the U.S. Gap Analysis Project mapped 209 ecological systems that are defined as groups of plant community types that tend to co-occur within landscapes with similar ecological processes, geology, soils, or ranges of environmental attributes such as elevation and precipitation (Fleishman et al. 2013). Most climate-based projections of species' distributions are based on an assumption of climate stability; however, the recently observed changes in climate indicate that shifts are occurring for some species in regions where climate change has been noted.

The discussions below provide a summary of observed changes in species, communities, and ecosystems that have been changing in response to changes in climate and climatic features such as evapotranspiration, temperature, and water supply. This discussion is not comprehensive, but gives an overview of selected species where changes have been noted. Changes in climate may be reflected in plants with the development of leaves, blooms, fish spawning, and migrations of birds. Changes in precipitation clearly affect soils, vegetation, and carbon storage in arid regions (Fleishman et al. 2013).

3.2.4.1.4.1 Aquatic Systems

Important aquatic resources within the project analysis areas include game fish and special status aquatic species that occur in Lake Powell and the Colorado River both upstream and downstream of the Glen Canyon Dam and the San Juan River. In particular, federally listed fish species (bonytail, Colorado pikeminnow, humpback chub, and razorback sucker) are present in Lake Powell, the Colorado River and San Juan River. Aquatic habitat is limited within the proposed KMC analysis area, therefore, few special status aquatic species are present (Section 3.13).

Based on information provided in **Figure 3.2-2** (Colorado River Runoff) and in Hoerling et al. (2013), increasing air temperatures and decreasing flows in the Colorado River have been documented. Temperature and water flow or volume are key components of habitat for aquatic species. Currently, the magnitude of global climate change is such that its effect on freshwater fisheries and other aquatic species could easily be masked by natural variability or attributed to other anthropogenic causes such as overexploitation, deforestation, and land use (Ficke et al. 2007). Global climate change appears to represent an additional stressor to a mixture of other factors including pollution, overfishing, water diversion, and wide-spread introduction of nonnative fishes.

The effect of increased water temperature on aquatic habitat and species could include changes in water quality (i.e., dissolved oxygen) and biological conditions such as direct mortality from acute temperature stress, sublethal stress on physiological functions, and shifts in species distributions (Ficke et al. 2007). Distribution range shifts for most groups of species, including aquatic species, are more difficult to attribute to changes in climate because the climate signal is small, there are many confounding factors, differences between expected and observed range shifts are large, or variability within or between studies is high. Changes in flow patterns or flow volumes could affect key biological activities such as fish spawning, early stage development of eggs and young fish, and increased colonization of nonnative or invasive aquatic species (Garfin et al. 2013). Higher air temperatures also may cause changes in food for fish by affecting invertebrate development (Garfin et al. 2013). In North America, the Intergovernmental Panel on Climate Change (IPCC 2014b) predicted that coldwater fisheries likely would be negatively affected, warmwater fisheries would generally be positively affected, and cool water fisheries would have a mixture of positive and negative changes in terms of habitat conditions and species distribution and diversity.

Climate change effects on amphibian species would be related to habitat factors and ecological requirements. As mentioned for fish species, temperature and precipitation changes could affect population abundance and distribution patterns. Other climate-related changes could include effects on survival, growth, reproduction, food availability, predator-prey relationships, and increased risk to disease

(Blaustein et al. 2010). Changes in ambient air temperature also may influence the timing of breeding and periods of hibernation. See Section 3.13, Special Status Aquatic Resources.

3.2.4.1.4.2 Agriculture and Forestry

Frisvold et al. (2013) summarize the observed changes in forests in the U.S. Southwest, concluding that increased temperatures along with periods of drought have led to the outbreak of pine bark beetles, which has led to high mortality among pinyon pines. Rapid mortality of mature aspen groves also has been attributed to drought, enhanced by warmer temperatures, and various combinations of insects and pathogens.

With warmer temperatures, fuel flammability in forests increases along with standing tree mortality, which increases the incidence of forest and woodland burned by wildfires. The total annual area burned in the U.S. Southwest has increased more than 300 percent since the 1970s.

Agriculture in the U.S. Southwest, particularly in arid regions, is heavily dependent on irrigation. Agricultural uses of water in the region account for 79 percent of all water withdrawals (Frisvold et al. 2013). The extensive surface water infrastructure supports this water storage and delivery system. Many locations are dependent on groundwater for irrigation. Depletion of the groundwater reserves and reductions in stream flow have presented increased costs for this sector. In some areas of northeastern Arizona, on the Navajo Nation lands, groundwater withdrawals supply over 75 percent of the total irrigation demand. Under warmer conditions, agricultural pests can persist year-round while new pests and diseases may become established.

3.2.4.1.5 Human Health

Topographical and climate variability in the U.S. Southwest is greater than any other region in the U.S. As a result, there is a wider range of vulnerability of human populations to any stress. Based on death certificates, an estimated 400 deaths per year are attributed to heat stress, and the largest number occur in Arizona. Records of heat related illnesses have been declining over the past years, largely due to increased air conditioning available to more of the population. However, this decline may not be true for tribal communities where there is a lack of infrastructure. There is no clear trend of human health conditions directly related to current changes in climate. The IWG on Climate Change and Health is targeting research efforts to establish direct links between climate change and research priorities related to human health categories considered likely to be affected by climate change.

3.2.4.1.6 Energy

Energy consumption in the U.S. Southwest has increased substantially since 2000, along with an increase in population. An important aspect of the changing climate is the peak use of electric power during the summer cooling season. Increasing temperatures and population have led to continued rapid increases in peak power demand in Arizona and other states.

A report prepared for the National Climate Assessment concluded that "Energy supplies will become less reliable as climate changes and climate change will drive increasing energy demand in some areas. Delivery of electricity may become more vulnerable to disruption due to extreme heat and drought events that increase demand for home and commercial cooling, reduce thermal power plant efficiency or ability to operate, reduce hydropower production, or reduce or disrupt transmission of energy" (Garfin et al. 2013).

Energy demand in the region outpaces production, leading to an increase in vulnerability of the regional electric power supply. Although current supply can meet the consumption through interstate transportation, under the current changing climate, the power generation sector is becoming more vulnerable to climatic effects such as increased temperatures (related to peak demand) and drought effects on hydropower production. Increased temperatures reduce the effectiveness of natural gas turbine power generation and increase power loss on transmission lines (summarized from Tidwell et al. 2013).

3.2.4.1.7 Socioeconomics

Section 3.18.4 presents the major income and fiscal benefits of the Proposed Action and alternatives that would accrue in the region. However, it does not estimate many other economic effects such as the value of providing reliable, low cost electricity for NGS utility customers, including the Central Arizona Project; the economic contributions to current domestic production from use of that electricity; or long-term benefits provided by capital investment in housing and commercial and public infrastructure supported directly and indirectly by the direct income and tax benefits. Addressing such effects is not within the scope of a site-/project-specific assessment such as the current effort. Section 3.18.4 acknowledges that there also may be public and social costs associated with each alternative. Potential costs would include the SCC associated with contributions in global CO_2 emissions from NGS and alternative sources that would result from implementation of the Proposed Action and alternatives.

A changing climate poses challenges to the global social and economic structure as well as potential impacts on the natural environment. Climate change has the potential to affect most aspects of the socioeconomic environment including economic conditions, population migration and settlement patterns, housing, public infrastructure and services, and fiscal and social conditions. In addition, a location's specific physical, economic, social, and cultural setting can intensify or dampen the socioeconomic effects of climate change. For example, communities with more abundant and diverse fiscal, natural and infrastructure resources may be more able to implement adaptation strategies to lessen climate change effects.

The three NGS generating units are among the 552 power plants and major sources (units) nationwide that collectively emit approximately 1.57 billion tons of CO_2. NGS emissions were approximately 1 percent of the total CO_2 emissions from those power plants and major sources. However, information regarding the timing, type, magnitude, and scale of climatic changes that would be associated with future emissions under the Proposed Action and the subsequent effects of those changes on local social and economic conditions are not available. Consequently, the discussion of socioeconomic effects focuses on the anticipated effects of climate change in general during the assessment period (2020 to 2044).

Socioeconomic conditions that may be affected by climate change include the availability and reliability of water for domestic, agricultural, municipal and industrial uses, and to sustain surface water features such as seeps, wetlands, rivers, streams, lakes and reservoirs. In addition to providing water for human use, these water features support plant and animal life, tourism, and outdoor recreation and comprise an important amenity value for residents and visitors alike. Temperature and precipitation-related changes in vegetation also can positively or negatively affect wildlife, tourism, outdoor recreation, food production, public infrastructure, and the livability of an area. Wildfires, floods, and extreme weather events also can affect socioeconomic, conditions.

3.2.4.1.7.1 Regional Economic Base of Northeastern Arizona

Key economic drivers in northeastern Arizona include tourism and outdoor recreation; government (federal, state, Tribal, and local); manufacturing; health care; science and research development; agriculture; coal mining; electric power generation; and transportation. Although the majority of these activities are indirectly sensitive to climate change, agriculture, tourism, and outdoor recreation are particularly sensitive to the potential effects of climate change. Some of the sensitivities of these sectors to climate are described below.

<u>Agriculture and Livestock</u>

Agriculture is a small but relatively important segment of the study area's economic base and socioeconomic environment. As with other areas of the U.S. Southwest, agriculture in the study area is heavily dependent on groundwater for irrigation. On the Navajo Nation lands, groundwater withdrawals supply over 75 percent of the total irrigation demand. Depletion of the groundwater reserves and reductions in stream flow have resulted in increased costs for this sector. Under warmer conditions, agricultural pests can persist year-round while new pests and diseases may become established. Water also is important for livestock. With the decrease in the number and flow rates of springs and other surface water described above, many Navajo presently haul water for their livestock.

Tourism and Outdoor Recreation

Tourism, outdoor recreation, and the associated hospitality/leisure industry are among the main drivers of the Coconino County economy, and a variety of businesses in the county are dependent on the natural environment (Coconino County 2015b). Tourism and recreation also are principal industries of the Navajo County economy (Navajo County 2011). The Navajo Nation 2015 to 2019 Navajo Tourism Strategic Plan concludes, "there are significant gains to be made by more heavily relying upon tourism development as a vital component of economic development activities throughout Navajo Nation" (Navajo Tourism Department 2015).

While some assessment of the effects on tourism from climate change is underway, such effects cannot be singled out from assessment of the global economic and socioeconomic response to climate change (United Nations World Trade Organization). Tourism is a climate-dependent industry, and many destinations owe their popularity to their pleasant climates during traditional holiday seasons (Amelung et al. 2007). Current literature also does not provide a clear review of any changes to tourism in the region currently resulting from climate change.

Tourism and outdoor recreation can be affected by extreme temperatures, drought, flooding, declines in river flows and other surface waters, changes in ecosystems, vegetation and land cover, wildland fires, and changes in the seasonal timing and duration of events relative to vacation, school, and holiday schedules as well as other factors that affect travel and recreation participation.

3.2.4.1.7.2 Public Water Supplies

Public water supplies can be directly and indirectly affected by drought and a changing climate. Within the study area, the City of Page, some communities on the Navajo Nation, and the NGS obtain water from the Colorado River. Although other surface water resources are used, most water in the region is obtained from groundwater. Groundwater is the most heavily utilized and dependable municipal water source for the Navajo Nation, particularly for those communities served by the Navajo Tribal Utility Authority (2015). Municipal use of reclaimed water for non-potable purposes is increasing (Coconino County 2015a).

As described in Section 3.18, many rural Navajo do not have residential water service and must haul water from chapter or privately operated wells. Flagstaff draws water from a reservoir and groundwater. Reservoir levels have been variable as a result of drought conditions that began in the 1990s, causing the city to be increasingly reliant on groundwater resources (Coconino County 2015a). Throughout the region, surface water features have been diminishing as a result of the drought and changing climatic conditions (Redsteer et al. 2015).

3.2.4.1.7.3 Sociocultural

Native Americans living within the U.S. Southwest are particularly vulnerable to the effects of climate change (Redsteer et al. 2013). Agriculture (grazing and small scale farming) is particularly important for many rural Navajo and Hopi families to provide basic components of their diet, as a traditional cultural activity, and in some cases, as a means to supplement their incomes. Population growth and relocation have resulted in competition for grazing land and, in some cases, water. Poverty limits the ability to develop and implement climate-related adaptation measures (Redsteer et al. 2013). As described in the following sections, recent research has furthered the understanding of the effects of climate and drought on the Navajo Nation and Hopi Tribe.

Navajo Nation

Many Navajo raise livestock and engage in small-scale farming and herb gathering for subsistence to maintain cultural traditions and to supplement their income. Population growth on the Navajo Nation over the last century and relocation of thousands of Navajo families associated with the passage and implementation of the 1974 Navajo-Hopi Land Settlement Act, as amended in 1980, resulted in competition for grazing lands and water and, in some cases, overgrazing on Navajo grazing lands. Changes in traditional grazing practices resulting from stock reduction programs and federally imposed grazing restrictions beginning in the 1930s limited the Navajo traditional drought adaptation practices of relocating livestock to an extended family's customary use area with more favorable conditions during times of drought (Redsteer et al. 2015).

In a study conducted on the Navajo Nation, 73 tribal elders were interviewed to refine the understanding of the effects of climate change on Navajo traditions, culture, and wellbeing, and to determine how these effects are magnified by historic changes in land tenure policies and economic conditions. Navajo elders who participated in the study reported a long-term decrease in snowfall in the latter half of the 20th Century, a decline in surface water features and water availability, springs and lakes drying up, and ephemeral washes and rivers flowing less often. Although all ecosystem impacts could not be attributed to changes in snowpack and increasing temperatures, the study concluded, "…changes to religious practices, farming, plants, animals, and water supplies have certainly been affected by a drying climate. Already dire conditions of increasing population pressures, poor socioeconomic conditions, and a limited resource base have acted in combination with climatic change to push the viability of living on Navajo land to its limit" (Redsteer et al. 2015).

Specific conclusions of the study include the following:

- "Climate change impacts have contributed significantly to poor living conditions on Navajo reservation lands. This region is characterized by harsh, dry conditions and sparse water supplies, even during normal conditions, and therefore is more vulnerable. The relocation of Navajo families from land allocated to the Hopi tribe has placed additional strain on local resources by increasing population pressures.
- Dire economic conditions and cultural ties to livestock add land use stresses that create greater risk and vulnerability from drought impacts and climate change.
- Lack of available water has undermined the ability of Navajo people to grow corn and other crops, and to collect corn pollen. Corn pollen is used for blessings and is central to every Navajo prayer and ceremony.
- Changes in springs, and plant and animal species have left ceremonialists without many of the resources necessary for traditional Navajo prayers, ceremonies, and offerings" (Redsteer et al. 2015).

Hopi Tribe

Corn is considered a cultural keystone species for the Hopi Tribe because of its importance in their diet, traditional values and cultural life. Hopi use labor-intensive dry farming methods to raise corn, one relying exclusively on precipitation and runoff rather than irrigation. Gardening also is culturally important for many Hopi, and Hopi gardens used to grow vegetables other than corn traditionally are irrigated by springs. Produce grown in Hopi gardens typically is consumed by the gardener's household and not sold (Rhodes 2013).

In a study on the Hopi Reservation, 35 elders, government employees, farmers, gardeners, ranchers, and others were interviewed on the topic of drought in order to understand Hopi perspectives on the causes of drought, to catalog Hopi people's observations of drought, to describe the negative impacts of drought, and to document current and proposed adaptation strategies for lessening those impacts. There was consensus among study participants that less overall rainfall was occurring, the timing of rainfall had shifted to later in the summer, and the pattern of rainfall was more patchy and unpredictable than in the past. Participants also reported less snowfall and a change from wet to powdery snow. Springs, which are an important source of water for household use, gardening, and for ceremonial use, also were reported as declining in terms of flow rates or disappearing altogether. Participants reported that the quantity and quality of vegetation had been affected by drought and cited a decline in native plants, the increasing pressures of non-native species, and overall poor range quality, all of which were generally attributed to a combination of dryness and overgrazing (Rhodes 2013).

Although individual Hopi farmers are implementing adaptive strategies, the most serious direct impact of drought on Hopi farming are lower yields or complete loss of the annual corn crop. As a cultural keystone species for the Hopi people, corn's "absolute centrality in the Hopi worldview, spiritual beliefs, diet, ceremonies, and life events makes it culturally more important than any other plant or animal species. Furthermore, because of the ubiquity of corn in the Hopi diet, the ability to procure Hopi varieties of corn through traditional methods – that is, farming – is a cornerstone of cultural food security for the Hopi people" (Rhodes 2013).

3.2.4.1.7.4 Socioeconomic Considerations in Central and Southern Arizona

The electrical supply provided by NGS creates an indirect socioeconomic linkage between the primary study area and areas in central and southern Arizona served by the CAP. Those areas include 10 Indian reservations; water utilities and districts; and agricultural interests in Maricopa, Pinal, and Pima counties. Between 1985 and 2010 the combined population of Maricopa, Pinal, and Pima counties more than doubled to 5.17 million residents, and more than 1.34 million net jobs were added (U.S. Bureau of Economic Analysis 2014). Between 2000 and 2010, the Maricopa County population grew by 24 percent, Pima County population grew by 16 percent, and Pinal County population increased by 109 percent. Together the three county area added a total of almost 1.1 million people between 2000 and 2010 (**Table 3.18-21**). As noted in Section 3.18.3.3, water availability, much of which is supplied by CAP, has been critical to the economic expansion and population growth of central and southern Arizona.

Additionally, the CAP system delivers approximately 1.6 million acre-feet of Arizona's Colorado River water entitlement. CAP supplies approximately 50 percent of the municipal water demand within Maricopa, Pima, and Pinal counties including 43 percent of the Phoenix supply and approximately 80 percent of the Tucson municipal water supply (CAWCD 2014). CAP water deliveries accounted for approximately 30 percent of statewide municipal and industrial water deliveries and 11 percent of water used for agriculture between 2007 and 2009. CAP supplies water for 21 percent of total farms and 16 percent of total agricultural acres in the state (Section 3.18.3.3). Contributions to the statewide gross domestic product associated with those deliveries was estimated to account for 32 percent of the total statewide gross domestic product during that same period (Seidman Institute 2014).

Given that the CAP obtains its water from the Colorado River, the decreasing Colorado River flow trend described in Section 3.2.3.1 and potential Stage I water shortage that could occur in 2016 (see Prospect of Stage I Water Shortages on the Colorado River subsection in Section 3.18.3.3), it is possible that CAP water deliveries would be reduced by 320,000 acre-feet per year.

If the shortage persists, fixed system costs would need to be absorbed by lower delivery volumes, potentially requiring rate increases. CAP's pumping energy requirements, along with the associated energy and transmission costs, would decline and potentially increase the availability of excess energy for sale. In the event of a more severe Stage II shortage, that would reduce CAPs annual allocation by an additional 80,000 acre-feet, the CAP plan would further curtail deliveries to the agricultural pool, while preserving the deliveries to priority customers. In addition to requiring further rate increases, regional economic output would decline as a result of the 400,000 acre-feet cutback in water deliveries (CAWCD 2015).

3.2.4.1.8 Social Cost of Carbon—Global

As an existing operation, future CO_2 and GHG emissions from NGS and the Kayenta Mine through the end of 2019 would contribute to global climate conditions. Although monetized values could be assigned to those emissions under the concept of the Social Cost of Carbon, those values would have limited meaning due to their low relative magnitude within a global context (USEPA 2016). However values for the EIS alternatives are presented for comparison purposes, from a Social Cost of Carbon perspective in the remainder of this section.

3.2.4.2 Assumptions and Impact Methodology

The environmental consequences of the Proposed Action and alternatives would take place in an era of a changing global climate. The consequences of any one action, even a major action, on global climate are impossible to predict; however, the predicted future of global and regional climate change is important to understand along with how the Proposed Action and alternatives are affected by the changing climate. This section provides an overview of the projected changes in global and regional climate, which serve as a backdrop for reporting magnitudes and relative contributions of the estimated GHG emissions of the Proposed Action and alternatives for the period 2020 to 2044. Comparative estimates of SCC associated with changes in operations of NGS and the Partial Federal Replacements (PFRs) also are presented.

3.2.4.2.1 Future Temperature Trends—Global and Regional

Various climate models have provided a wide range in predictions of global surface air temperature over the next decade. The IPCC (2013) report summarizes details of temperature and precipitation changes resulting from an array of global and regional atmospheric circulation models. A consensus was built around the results of multiple models that were run with a range of predicted increases in CO_2 emissions. Results have been developed for both a 3-Unit Operation and 2-Unit Operation, with the presumption that actual impacts would be within the predicted ranges.

While the Arctic region is predicted to receive the greatest increase in annual temperature, the western and southwestern portions of the U.S. also are regions where predicted increases in temperature are notable (**Figure 3.2-10**). Northern Arizona may experience up to 2°C annual average increase by mid-century under the low global emissions scenario and potentially up to 4°C under the high global emissions scenario (IPCC 2013). Based on a summary of model impacts (Cayan et al. 2013) as demonstrated for the different emissions scenarios in **Figure 3.2-10**, regional temperature increases could range from 2°C to approximately 5°C by the late 21st Century.

According to IPCC (2013), global warming of approximately 2°C (above the pre-industrial baseline) is very likely to lead to more frequent extreme heat events and daily precipitation extremes over most areas of North America, more frequent low snow years, and shifts towards earlier snowmelt runoff over much of the western U.S. and Canada (IPCC 2013). Together with climate hazards such as higher sea levels and associated storm surges, more intense droughts, and increased precipitation variability, these changes are projected to lead to increased stresses to water, agriculture, economic activities and urban and rural settlements. **Figure 3.2-10** (IPCC 2013) predicts an increase in temperature of 2°C or more for the U.S. Southwest by the middle of the 21st Century.

Global warming of approximately 4°C is very likely to cause larger changes in extreme heat events, daily scale precipitation extremes and snow accumulation and runoff, as well as emergence of a locally novel temperature regime throughout North America (IPCC 2013).

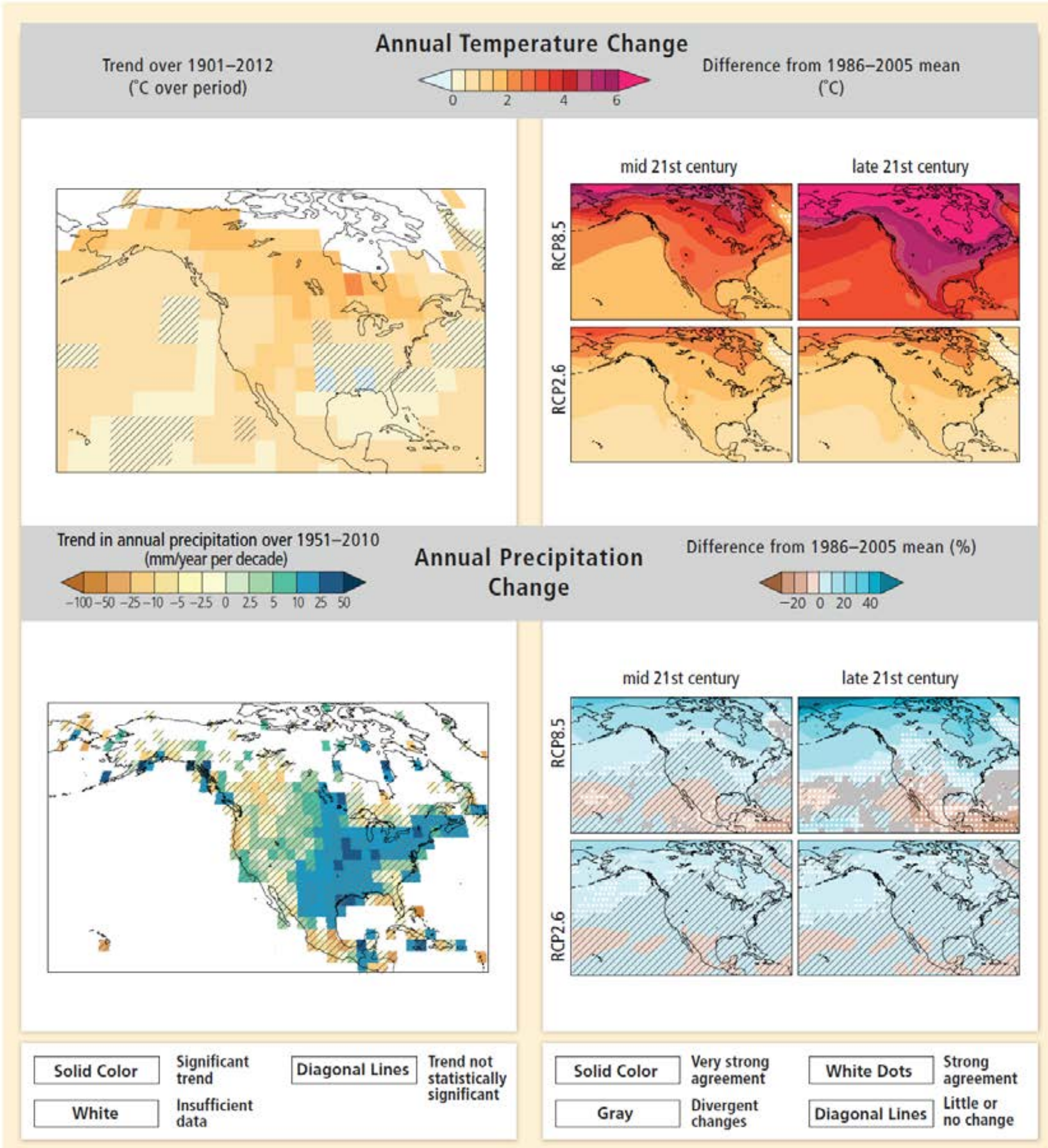


Figure 26-3 | Observed and projected changes in annual average temperature and precipitation. (Top panel, left) Map of observed annual average temperature change from 1901–2012, derived from a linear trend. [WGI AR5 Figures SPM.1 and 2.21] (Bottom panel, left) Map of observed annual precipitation change from 1951–2010, derived from a linear trend. [WGI AR5 Figures SPM.2 and 2.29] For observed temperature and precipitation, trends have been calculated where sufficient data permit a robust estimate (i.e., only for grid boxes with greater than 70% complete records and more than 20% data availability in the first and last 10% of the time period). Other areas are white. Solid colors indicate areas where trends are significant at the 10% level. Diagonal lines indicate areas where trends are not significant. (Top and bottom panel, right) CMIP5 multi-model mean projections of annual average temperature changes and average percent changes in annual mean precipitation for 2046–2065 and 2081–2100 under RCP2.6 and 8.5, relative to 1986–2005. Solid colors indicate areas with very strong agreement, where the multi-model mean change is greater than twice the baseline variability (natural internal variability in 20-yr means) and ≥90% of models agree on sign of change. Colors with white dots indicate areas with strong agreement, where ≥66% of models show change greater than the baseline variability and ≥66% of models agree on sign of change. Gray indicates areas with divergent changes, where ≥66% of models show change greater than the baseline variability, but <66% agree on sign of change. Colors with diagonal lines indicate areas with little or no change, where <66% of models show change greater than the baseline variability, although there may be significant change at shorter timescales such as seasons, months, or days. Analysis uses model data and methods building from WGI AR5 Figure SPM.8. See also Annex I of WGI AR5. [Boxes 21-2 and CC-RC]

Source: Reproduced from IPCC 2013.

Figure 3.2-10 Observed and Predicted Changes in Annual Average Temperature and Annual Precipitation

The observed and predicted increase in surface temperatures also would have an effect on the length of the local growing season. Cayan et al. (2013) predict that the average growing season length would increase by 24 to 31 days per year for the period 2041 to 2070 when compared to 1971-2000. This projection would result in an ongoing trend in the increase in the length of the growing season by approximately 1 day every 3 years. The effect may differ within the different climate areas, even within the Navajo Nation and Hopi Reservation lands, but there is confidence that the length of the growing season likely would increase.

3.2.4.2.2 Model Precipitation Predictions

Predicted change in regional precipitation is less clear than for regional temperatures for the 21st Century. The Proposed Action is in a region where the model predictions are not clear and are not statistically significant, as shown in **Figure 3.2-10.** Northern Arizona is in the area where a near-zero change in percent of annual precipitation is predicted. For higher emissions, the models predict a slight (0 to 10 percent) increase in annual precipitation in the region; however, that increase is determined to be not significant (IPCC 2013). The IPCC panel indicates low confidence in determining a trend in precipitation that is associated with changing climate. Any trend in precipitation is generally very small in comparison to the variability in the historical record and in comparison to the variability among the model results (Cayan et al. 2013).

The discussion of predictions in climate change is intended to show how local changes are occurring, and to the extent available, understand how a changing climate affects water supply and other resources that are analyzed in this EIS.

Over the U.S. Southwest, the prediction related to the primary seasonal precipitation features is less clear. Most models predict an increase in winter precipitation (i.e., December, January, and February) with a slight tendency for reduced precipitation in other seasons (Cayan et al. 2013). However, the precipitation pattern includes a projection of more rainfall and less snow, resulting in lower spring snowpack levels, earlier snowmelt, and a reduction in late-spring and summer runoff from mountainous areas. Projected Colorado River flows are expected to show possible reduction from climate change impacts ranging from approximately -5 percent to -20 percent of the current annual flow by mid-century.

There is a weak level of consensus about predicted changes in the Southwest Monsoon circulation, which reflects the challenge of representing the monsoon circulation in a global atmospheric model (Cayan et al. 2013). The interannual variability of the monsoon precipitation is partially dependent on the large scale features such as the El Niño Southern Oscillation and the Pacific Decadal Oscillation; however, the global circulation models exhibit large uncertainty in predicting these features. Furthermore the precipitation during the North American Monsoon is dependent on fine scale features, including thunderstorms and convective activity. Therefore, the ability to predict the nature of the precipitation patterns related to the North American Monsoon is very low.

IPCC (2013) provides a consensus that there is low confidence in projections of precipitation changes for the North American Monsoon, but medium confidence that the North American Monsoon will arrive and persist later in the annual cycle.

3.2.4.2.3 Global GHG Levels and Emissions

Stocker et al. (2013) provides a technical summary overview of GHG levels in the atmosphere, and indicates that by 2035, global average CO_2 concentrations will range between approximately 425 ppm and 500 ppm. Total annual fossil-fuel carbon emissions projected for 2040 are approximately 43 billion metric tons (43×10^{15} grams), which is up from an estimated 34 billion metric tons in 2015 (Statista 2016).

3.2.4.2.4 Social Cost of Carbon

In the context of this NEPA assessment, the federal SCC concept "…is an estimate of the monetized damages associated with an incremental increase in CO_2 emissions in a given year.[1] SCC estimates are intended to include (but are not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change." One purpose of SCC estimates is to allow agencies to incorporate values for the social benefits of reducing CO_2 emissions (sometimes referred to as avoided damages) into cost-benefit analyses of regulatory actions that impact cumulative global emissions (IWG on SCC 2015).

The annual emissions of CO_2 associated with NGS and the PFR alternatives, prepared as part of this analysis (Section 3.2.4) and expressed in metric tons per year (tpy), are multiplied by the federal SCC per metric ton values developed by the IWG on SCC and discounted to a present value.[2] Those values reflect averages of the results produced by three integrated assessment models discounted to present values using discount rates of 2.5, 3, and 5 percent. The series of discounted annual values are then summed to obtain a total value for the period 2020 through 2044, which is the assumed operating life of the NGS under the Proposed Action and alternatives.

The estimated SCC values associated with a metric ton of carbon emissions used in this assessment are presented in **Table 3.2-1**, and those values were used to calculate the projected SCC for the Proposed Action and each of the alternatives. The presentation of multiple discount rates recognizes uncertainty regarding the appropriate discount rate for long-term changes that would span multiple generations.

Table 3.2-1 Estimated Social Cost of Carbon

Year	SCC Value for Discount Rate (2015 USD/Metric ton CO_2)			95th Percentile / 3% Discount Rate
	5.0% Rate	3.0% Rate	2.5% Rate	
2020	14	49	75	148
2025	16	55	81	166
2030	18	60	87	183
2035	22	66	93	202
2040	24	71	100	221
2044	26	75	105	233

Note: 2015 values are 2007 values inflated by 1.15 based on changes in the Consumer Price Index.

USD = U.S. dollars.

Source: IWG on SCC 2013; U.S. Bureau of Labor Statistics 2016.

The IWG on SCC (2015) also published a fourth set of SCC values. Those values, termed the 95th percentile at a 3 percent discount rate (95^{th} / 3 percent) in reference to the statistical construct it represents, are intended to capture virtually the entire range of high and low values of the long-term results produced by 45 scenarios evaluated by the three integrated assessment models. The 95^{th} / 3 percent value is considerably higher than the other three sets of values as it accounts for higher

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[1] The term "monetized" refers to estimates of the economic values of costs or benefits, expressed in terms of an equivalent monetary value, that are not expressly quantifiable or observable through normal market transactions. For example, although entry and use of wilderness typically carries no entry fee, a study of 20 empirical studies of the economic value of recreation in wilderness reported an average value of $39 per recreation day (Loomis 2000).

[2] Per the draft CEQ guidance, the SCC analysis is based on tons of CO_2 emissions rather the broader CO_2e, or CO_2 equivalents.

degrees of uncertainty regarding the incremental damages to physical and economic systems that become more stressed in response to climatic change over the long-term (IWG on SCC 2015).

The IWG has acknowledged serious challenges and inherent limitations in assessing the incremental economic impacts of CO_2 emissions, recognizing that a "number of key uncertainties remain" and that current SCC estimates should be treated as provisional and revisable because they will evolve with improved scientific and economic understanding. The federal estimates of SCC also are the subject of ongoing review and critique. For example, a 2014 technical assessment of the SCC recommended that the current experimental design using three divergent models be revisited, and that additional guidance be provided on the proper use of SCC to avoid misapplication. The study further concluded that "…SCC estimates are difficult to interpret, discuss, and evaluate in terms of the societal risks they do and do not represent…" (Rose et al. 2014).

3.2.4.3 Proposed Action

3.2.4.3.1 Emissions

3.2.4.3.1.1 Navajo Generating Station

The GHG emissions from the Proposed Action primarily are related to the combustion of coal at NGS, and this is directly related to the level of power production in each of the Proposed Action operations. Results have been developed for both a 3-Unit Operation and 2-Unit Operation, with the presumption that actual impacts would be within the predicted ranges. A rough estimate of GHG emissions from NGS operations also is provided, based on estimates of fuel use and oil combustion. Predicted GHG emissions are provided in **Table 3.2-2**, both for CO_2e and CO_2, and backup calculations are provided in **Appendix 3.2-C** Exhibit 1. The estimates are based on an annual 88 percent capacity factor, and use the following assumed conversion factors (from 40 CFR Part 98 Tables C-1 and C-2, and Subpart A), and the heat rate data provided by NGS.

- 93.28 kilograms CO_2 per million British Thermal Units of coal combustion.
- 0.011 kilograms methane per million British Thermal Units of coal combustion, CO_2e weight of 25.
- 0.0016 kilograms nitrous oxide per million British Thermal Units of coal combustion, CO_2e weight of 298.
- Gross NGS heat rate of 11,194 British Thermal Unit/kilowatt-hour, or 11.194 million British Thermal Units/megawatt-hour.

Table 3.2-2 GHG Emissions from NGS for the Proposed Action

	3-Unit Operation	2-Unit Operation
NGS Generation (megawatt [MW], 88 percent capacity factor)	1980	1320
Annual CO_2e Emissions (metric tons)		
NGS Generation	18,257,000	12,171,000
NGS Support Operations	130,000	130,000
Total Rounded	18,387,000	12,301,000
Annual CO_2 Emissions (metric tons)		
NGS Generation	18,111,000	12,074,000
NGS Support Operations	129,000	129,000
Total Rounded	18,240,000	12,203,000

The Black Mesa & Lake Powell Railroad is operated on electric power provided by NGS; therefore, it has no additional GHG emissions except for fuel burning equipment that provides routine and emergency maintenance and repair.

3.2.4.3.1.2 Proposed Kayenta Mine Complex

Methane may be released from surface coal mining operations, including emissions from mining and coal handling. Kirchgessner et al. (2000) estimated methane content from coal mined from western surface coal mines at 0.17 pound per ton of coal. Given the approximate coal mining for the 8.1 million tpy Operation, the total methane released during mining, handling storage, or processing is estimated to be 689 tpy. With methane's global warming potential of 25, this equates to 15,600 metric tons of CO_2e. For the 5.5 million tpy Operation, an estimated 468 tpy of methane would be emitted. This equates to 10,600 metric tons of CO_2e.

Fuel use for mining operations, including diesel-fired mining equipment, vehicle traffic, and hauling operations at the proposed KMC, was based on an estimated 5.4 million gallons of diesel fuel for the operating equipment for the 8.1 million tpy Operation. For the 5.5 million tpy Operation, estimated annual fuel use would be 4.2 million gallons of diesel fuel for the operating equipment. That analysis uses diesel fuel emissions data from 40 CFR Part 98 Tables C-1 and C-2, and an assumed sulfur content of 15 parts per million by volume along with the projected equipment SO_2 emissions for the proposed KMC operations. Detailed backup calculations are provided in **Appendix 3.2-C**, Exhibit 2.

Table 3.2-3 provides a summary of total GHG emissions from coal mining operation based on a prorated coal production level.

Table 3.2-3 GHG Emissions from Proposed KMC for the Proposed Action

Proposed KMC Total Coal Production (million tpy)	Emissions (metric tpy in CO_2e)		
	Methane	**Equipment**	**Total**
8.1	15,600	55,300	71,000
5.5	10,600	43,400	54,000

The table includes GHG (methane) emissions from coal mining and production GHG emissions from proposed KMC operations.

The range for configuration is provided for each operation, based strictly on the coal production at proposed KMC. This level of annual production was calculated to meet the power generation.

3.2.4.3.1.3 Transmission Systems and Communication Sites

Except for the GHG emissions from maintenance operations and incidences of on-site emergency power generation (less than 10 metric tons annually), there would be no other GHG emissions associated with the transmission lines and communication sites (**Appendix 3.2-C**, Exhibit 3). The transmission system and communication sites would have no effect on GHG emissions because there would be a very small amount generated during future operation and maintenance. The effects of natural variability in climate conditions would be greater than any projected change in climate conditions related to these operations.

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

No new construction is proposed for the transmission lines and activities along the lines would be limited to routine and periodic major maintenance. Consequently, future climate change effects on these facilities and activities likely would be limited to the increased potential for damage associated with extreme weather events and wildfires, which could require additional maintenance or reconstruction of transmission lines and communication sites. The impacts of such events likely would be localized, short-term, and unpredictable in occurrence and intensity.

3.2.4.3.1.4 Project Impact Summary – All Project Components

Table 3.2-4 provides a summary for all project emissions from NGS and proposed KMC. Emissions from transmission lines and communication sites would be negligible.

Table 3.2-4 Total Project GHG Emissions for Proposed Action and Contribution to Projected Global Emissions in 2040

NGS Operation	Emissions (tpy in CO_2e)			Fraction of Global CO_2e Emissions in 2040 [1]
	NGS	Proposed KMC	Total Proposed Action	
3-Unit Operation	18,387,000	71,000[2]	18,458,000	0.00026
2-Unit Operation	12,301,000	54,000[3]	12,355,000	0.00018

[1] Calculated from Organisation for Economic Cooperation and Development (2011) 70 Giga-tonnes/year (70 X 10^{15} g).

[2] Value represents 8.1 million tpy coal production.

[3] Value represents 5.5 million tpy coal production.

3.2.4.3.1.5 Cumulative Impacts

The combined NGS and Kayenta Mine operations released approximately 20 million metric tons of CO_2e during 2014, which is approximately 0.055 percent of the total global GHG emissions and 0.28 percent of the total U.S. GHG emissions.

There are a variety of estimates for future increases in global GHG. One example (Organisation for Economic Cooperation and Development 2011) estimates 52 giga-tonnes of GHG would be emitted, with an increase to 80 giga-tonnes by 2050 (**Table 3.2-5**). The total GHG emissions for the project from all operations were compiled for the Proposed Action and would range from a high of 18,336,000 metric tons annually for the 3-Unit Operation to a low of 12,266,000 metric tons annually for the 2-Unit Operation. GHG contributions for NGS for the operating period of 2020 to 2044 were compared to the GHG global estimated increases. The Organization for Economic Cooperation and Development data projects an 80 percent increase in global energy demand, driven largely by major emerging economies and including a strong demand for vehicles and their resultant emissions. Cumulative global CO_2e emissions would increase by 52 percent from 2020 to 2050, a major impact (**Table 3.2-5**). The trend data show that NGS would contribute a declining percentage of global GHG because NGS emissions would remain relatively constant through this operating period.

Table 3.2-5 Total Proposed Action Contribution to Global GHG Emissions

Operation	3-Unit Operation	2-Unit Operation
	(Metric Tons of CO_2e) [1]	
Total Project Emissions – Proposed Action	18,458,000	12,355,000
Proposed Action Fraction of Global CO_2e (52 giga-tonnes in 2020) [2]	0.00035	0.00023
Proposed Action Fraction of Global CO_2e (61 giga-tonnes in 2030) [2]	0.00030	0.00020
Proposed Action Fraction of Global CO_2e (70 giga-tonnes in 2040) [2]	0.00025	0.00017
Proposed Action Fraction of Global CO_2e (80 giga-tonnes in 2050) [2]	0.00023	0.00015

[1] Data rounded to nearest 1,000.

[2] Data from Organisation for Economic Cooperation and Development (2011). giga-tonne = 10^9 metric tonnes = 10^{15} g.

3.2.4.3.2 Socioeconomics

While acknowledging the uncertainty associated with predicting the effects of future climate changes on the environment and society, Garfin et al. (2013) concluded with medium-high confidence that a large portion of the U.S. Southwest, including most of the region's major river systems such as the Colorado River, would be expected to experience reductions in stream flows and other limitations on water availability in the 21st Century. Overpeck et al. (2013) concluded with high confidence that water availability could be decreased even more by unusually warm, decades-long periods of drought. Reclamation (2016) confirmed that, absent future action, the basin faces a wide range of plausible future long-term imbalances between supply and demand, ranging from 0 to 6.8 million acre-feet per year. The effects of such reductions would include decreased availability and reliability of water for domestic, agricultural, municipal, and industrial uses as well as decreased flow and an increased rate of disappearance of some surface water features such as springs and seeps.

Warming temperatures, potential changes in precipitation patterns, and the resultant effects on the physical and biological environment described in the preceding sections likely would result in a continuation and intensification of the recent effects on socioeconomic resources described in Section 3.2.4.1.

Population growth in the region is forecast to continue to grow through 2050 (Section 3.18.3.3). It is unknown whether and how climate changes would affect future growth. If the population continues to increase as currently forecast, demand for water, energy, and infrastructure would increase with population growth and the associated economic expansion. Rising temperatures, increases in wildfire (Fleishman et al. 2013), heat waves, and floods (although there is some uncertainty about the latter) (Gershunov et al. 2013) could affect the cost of living and the cost of providing public services including water and wastewater infrastructure in the affected areas. Rising temperatures also may increase energy demand, stressing existing energy generation and distribution systems and requiring additional generating facilities.

Rising temperatures along with decreases in snowfall and runoff likely would contribute to lower water storage volumes and elevations in Lake Powell, which in turn could adversely affect tourism and recreation in Page, Grand Canyon National Park, Navajo National Monument and other attractions. Potential climate change effects at those locations could include effects on plant and animal species and operations, which are indirectly linked to visitation and the local economic activity supported thereby. Similarly, climate change could affect outdoor recreation on the National Forests. Changes in precipitation patterns and rising temperatures would increase risk of wildland fires, which could further affect recreation and tourism in the region.

As noted in Section 3.2.4.1, many Navajo and Hopi rely on grazing, small-scale farming, and plant gathering, for subsistence, maintenance of cultural traditions, and in some cases, for supplementing their income. Grazing and small scale farming are both reliant on precipitation, springs, and seeps. Given current scarcity of water, even relatively modest changes in water availability could be detrimental for those activities on a localized level. Overpeck et al. (2013) concluded with high confidence that “Effects of climate change on the lands and people of Southwestern Native nations are likely to be greater than elsewhere because of endangered cultural practices, limited water rights, and social, economic, and political marginalization, all of which are relatively common among indigenous people.” Such effects could extend to certain indigenous plants and animals that are culturally important for Navajo and necessary for their traditional religious practices.

Population on the Navajo Nation and Hopi Reservation likely would grow during the period from 2020 to 2044. However, the effects on agriculture and grazing defined above could result in increased off-reservation emigration of Navajo and Hopi for economic and quality-of-life purposes.

Although many Tribes, local and state governments, and water entities are developing strategies for adapting to a changing climate (Pincetl 2013; Redsteer et al. 2013; Udall 2013), the availability of resources to implement these strategies and their subsequent effectiveness are uncertain.

Strong population growth is forecast to continue in the coming decades (Section 3.18.3.3). The Arizona Department of Administration medium series forecasts for 2050 call for an 81 percent increase in population in Maricopa County, a 55 percent increase in population in Pima County, and a 229 percent increase in Pinal County. Under those forecasts the three county region would gain an additional 4.5 million residents by 2050.

Warming temperatures, potential changes in precipitation patterns, and the resultant effects on the physical and biological environment described in the preceding sections could have similar effects on the reservations, water utility, and agricultural interests in Maricopa, Pinal, and Pima counties to those described for the study area. Additionally, forecast reductions in Colorado River flows as well as the CAP system and its water delivery, would occur as described in Section 3.2.3.

Priority allocations for municipal and industrial, reservations, and non-reservation priority customers would not be affected. It is not known whether the climate change effects forecasted for the assessment period would result in reduced deliveries of excess water to the Arizona Water Banking Authority, groundwater replenishment programs, and the agricultural settlement pool. Fixed operations and maintenance costs would have to be absorbed by lower delivery volumes, requiring rate increases. Pumping energy requirements for CAP and associated energy and transmission costs would decline, potentially increasing the availability of excess energy for sale as surplus.

According to the CAWCD (2015), the agency and the Arizona Department of Water Resources are taking proactive steps to protect against the impacts of Colorado River water shortage, including storing water underground water storage, aquifer recharge programs, water efficiencies, desalinization programs, cloud seeding, and Lake Mead water storage programs.

Extended shortages of Colorado River water also would affect the overall pricing and demand for water in central and southern Arizona. A possible scenario would be higher interest in converting water from agricultural use to municipal and industrial use, with that interest expressed through higher offer prices for water. Whether this would occur, what future price levels might be, and what parties might be involved are all unknown.

Reductions in CAP water provided to agricultural users could result in lower agricultural production and reduced profitability of farms that rely on CAP water. However, “In the face of potential shortage, farmers in central Arizona may choose to offset supply reductions in their CAP supply by using local supplies including pumping groundwater” (CAWCD 2015).

Climate changes on socioeconomic conditions in the study area and in central and southern Arizona under either the 3-Unit Operation or 2-Unit Operation would be minor. Future emissions from NGS and the proposed KMC would be a very small increment within the context of future global emissions and likely would be too small to materially affect climatic influences in the region. NGS contributes approximately 2 percent of coal-fired generation nationally.

3.2.4.3.3 Social Cost of Carbon

Table 3.2-6 displays the estimated cumulative SCC for NGS under the Proposed Action over the 2020 to 2044 period based on the current IWG values and 3 percent and 5 percent discount rates.

Table 3.2-6 Social Cost of Carbon for the Proposed Action

NGS Operation	Annual CO_2 Emissions (metric tons)	SCC Present Value for 2020 to 2044 (2015 USD)		
		At 3% Discount ($ millions)	At 5% Discount ($ millions)	95th Percentile At 3% Discount ($ millions)
3-Unit Operation	18,240,000	$28,453	$9,121	$87,042
2-Unit Operation	12,203,000	$19,036	$6,099	$58,230

Based on the IWG on SCC values per metric ton at a 3 percent discount rate and adjusted to 2015 dollars, the Proposed Action 3-Unit Operation NGS emissions would generate an estimated SCC of $28,453 million over the period from 2020 to 2044 period. The corresponding estimates of aggregate SCC at a 5 percent rate would be $9,121 million, and the 95th/3 percent would be $87,042 million.

The estimated SCC for the Proposed Action 2-Unit Operation would be $19,036 million from 2020 to 2044 for the 3 percent discount rate and 2015 USD. Using a 5 percent discount rate, the aggregate SCC from 2020 to 2044 would be an estimated $6,099 million, with aggregate SCC of $58,230 million for the 95th/3 percent. The SCC for the Proposed Action 2-Unit Operation would be 33 percent lower than those for the Proposed Action 3-Unit Operation, which reflects the effects of shutting down one generating unit at NGS.

Because the PFR alternatives would affect only the federal share of NGS production, and thereby also account for the changes in coal production from the proposed KMC, the SCC estimates for the NGS Proposed Action were adjusted to reflect the federal share of emissions. The resulting values, using the SCC present value discounted at 3 percent would be $6,914 million for the Proposed Action 3-Unit Operation and $6,852 million for the Proposed Action 2-Unit Operation (**Table 3.2-7**). Although the numerical values derived for the federal share of emissions using the 2.5 percent and the 95th percentile at 3 percent SCC values from **Table 3.2-6** would differ from those shown, the numerical relationship would be consistent.

Table 3.2-7 Social Cost of Carbon for the Federal Share of NGS

NGS Operation	Federal Share of Annual CO_2 Emissions (metric tons)	SCC Present Value for 2020 to 2044 (millions of 2015 USD)
3-Unit Operation	4,432,300	$6,914
2-Unit Operation	4,393,100	$6,853

3.2.4.4 Natural Gas Partial Federal Replacement Alternative

3.2.4.4.1 Emissions

3.2.4.4.1.1 Navajo Generating Station

Under the Natural Gas Partial Federal Replacement (PFR) Alternative, a selected quantity of power between 100 megawatts (MW) and 250 MW would be contracted for under a long-term power purchase agreement from currently unidentified, existing natural gas generation sources, displacing an equivalent amount of power from the federal share of NGS generation. GHG emissions from the replacement power were based on a recent permit for the Bowie Power Plant in Arizona (Arizona Department of Environmental Quality 2014), which provided an estimate of 995 pounds of CO_2 per MW-hour for a 1,000-MW combined cycle plant. Replacement power would be drawn from this type of unit; therefore, the GHG associated with the generation of that power has been included in the total GHG emissions for this alternative. **Table 3.2-8** provides a tabular summary of GHG emissions. Data are provided for emissions of CO_2e and CO_2 in metric tons. Detailed calculations are provided in **Appendix 3.2-D**. The CO_2 emission data were used in the evaluation of the SCC. Natural Gas PFR Alternative does not include power generation from renewable sources.

Table 3.2-8 GHG Emissions Associated with the Natural Gas PFR Alternative

Parameter	3-Unit Operation		2-Unit Operation	
	100-MW Replacement	250-MW Replacement	100-MW Replacement	250-MW Replacement
Annual CO_2e Emissions (metric tons)				
NGS Generation	17,335,000	15,952,000	11,249,000	9,866,000
Replacement Generation	395,000	988,000	395,000	988,000
NGS Support Operations	130,000	130,000	130,000	130,000
Total Rounded	17,860,000	17,070,000	11,774,000	10,984,000
Annual CO_2 Emissions (metric tons)				
NGS Generation	17,196,000	15,824,000	11,159,000	9,787,000
Replacement Generation	395,000	987,000	395,000	987,000
NGS Support Operations	129,000	129,000	129,000	129,000
Total Rounded	17,720,000	16,940,000	11,683,000	10,903,000

3.2.4.4.1.2 Proposed Kayenta Mine Complex

Under the Natural Gas PFR Alternative, the proposed KMC would produce the coal to meet the expected power generation at NGS. For purposes of the analysis of GHG emissions, the changes in coal production were used to estimate the changes in GHG emissions both from methane emissions from coal mine operations and from GHG emissions from equipment operations. **Table 3.2-9** provides total emission rates for the Natural Gas PFR Alternative from the proposed KMC operations based on the total production of coal.

Table 3.2-9 GHG Emissions from Proposed KMC for the Natural Gas PFR Alternative

Operation	Proposed KMC Total Coal Production (million tpy)	Emissions (metric tpy in CO_2e)		
		Methane	Equipment	Total [1]
3-Unit Operation	8.1	15,600	55,300	71,000
3-Unit with 100-MW Replacement	7.7	14,900	53,400	68,000
3-Unit with 250-MW Replacement	7.1	13,800	50,500	64,000
2-Unit Operation	5.5	10,600	43,000	54,000
2-Unit with 100-MW Replacement	5.1	9,900	41,000	51,000
2-Unit with 250-MW Replacement	4.5	8,700	28,100	47,000

[1] Data rounded to 1,000.

3.2.4.4.1.3 Transmission Systems and Communication Sites

Except for the GHG emissions from maintenance operations and incidences of on-site emergency power generation (less than 10 metric tons annually), there would be no other GHG emissions associated with the transmission lines and communication sites (**Appendix 3.2-C**, Exhibit 3). The transmission system and communication sites would have no effect on GHG emissions because there would be a very small amount generated during future operation and maintenance. The effects of natural variability in climate conditions would be greater than any projected change in climate conditions related to these operations.

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

No new construction is proposed for the transmission lines and activities along the lines would be limited to routine and periodic major maintenance. Consequently, future climate change effects on these facilities and activities likely would be limited to the increased potential for damage associated with extreme weather events and wildfires, which could require additional maintenance or reconstruction of transmission lines and communication sites. The impacts of such events likely would be localized, short-term, and unpredictable in occurrence and intensity.

3.2.4.4.1.4 Project Impact Summary – All Project Components

The combined GHG emissions from the Natural Gas PFR Alternative are provided in **Table 3.2-10**. The data show the total emissions from both NGS and proposed KMC as well as a comparison to the total global CO_2e emissions projected for 2040. The extraction, transportation, and storage of natural gas also would be sources of methane emissions contributing to total CO_2e emissions. A separate calculation of emissions associated with these sources of emissions for providing natural gas to a combined cycle power plant are provided in **Appendix 3.2-D**, The calculations show approximately 10,000 metric tonnes of CO_2e per 100 MW of power generation for 1 year. Those GHG emissions would be negligible in comparison to the total GHG generated by the Proposed Action.

Table 3.2-10 Total Project Contribution to Global GHG for the Natural Gas PFR Alternative

Operation	Emissions (tpy in CO_2e)			Fraction of Global CO_2e in 2040
	NGS	Proposed KMC	Total Natural Gas PFR[1]	
3-Unit Operation	18,387,000	71,000	18,458,000	0.00026
3-Unit with 100-MW Replacement	17,860,000	68,000	17,928,000	0.00026
3-Unit with 250-MW Replacement	17,070,000	64,000	17,134,000	0.00025
2-Unit Operation	12,301,000	54,000	12,355,000	0.00018
2-Unit with 100-MW Replacement	11,774,000	51,000	11,825,000	0.00018
3-Unit with 100-MW Replacement	10,984,000	47,000	11,031,000	0.00016

[1] Data rounded to 1,000.

3.2.4.4.1.5 Cumulative Impacts

Local cumulative impacts related to climate change cannot be directly assessed because impacts of GHG emissions are a global issue only. There may be localized cumulative effects on climate, but any conjecture would be purely speculative. The cumulative impacts from the various operations under the Natural Gas PFR Alternative were compared to the global total cumulative emission estimates during the proposed period of the Alternative operation. **Table 3.2-11** provides a comparison of the total GHG emissions as a fraction of that total, for the period 2020 through 2044 as well as out to 2050. Global CO2e emissions would increase by 52 percent from 2020 to 2050, a major impact (**Table 3.2-11**).

Table 3.2-11 Total Natural Gas PFR Alternative Contribution to Global GHG

Operation	Fraction of GHG Emissions from PFR Alternative to Global Total			
	2020	2030	2040	2050
3-Unit Operation				
3-Unit with 100-MW Replacement	0.00035	0.00029	0.00026	0.00022
3-Unit with 250-MW Replacement	0.00033	0.00028	0.00025	0.00021
2-Unit Operation				
2-Unit with 100-MW Replacement	0.00023	0.00019	0.00017	0.00015
3-Unit with 100-MW Replacement	0.00021	0.00018	0.00016	0.00014
Global Total CO_2e Emissions (giga-tonne)	52	61	70	80

Global Total CO_2e Emissions giga-tonne = 109 metric tonnes = 1,015 g.

3.2.4.4.2 Socioeconomics

Climate change effects on socioeconomic conditions in the study area and in central and southern Arizona under the any configuration of the Natural Gas PFR Alternative would be minor and the same as Proposed Action.

3.2.4.4.3 Social Cost of Carbon

Table 3.2-12 displays the estimated NGS SCC over the period from 2020 to 2044 based on the current IWG values (**Table 3.2-2**) for the Natural Gas PFR Alternative at 3 percent and 5 percent discount rates, as well as for the 95th percentile at 3 percent. The differences in SCC for the Natural Gas PFR Alternative compared to the corresponding Proposed Action operation also are presented.

Table 3.2-12 Social Cost of Carbon for the Natural Gas PFR Alternatives

NGS Operation	Annual CO_2 Emissions (metric tons)	SCC Present Value for 2020 to 2044 (2015 USD)			Difference Compared to the Proposed Action
		At 3% Discount ($ millions)	At 5% Discount ($ millions)	95th Percentile At 3% ($ millions)	
3-Unit Operation	18,240,000	$28,453	$9,121	$87,042	NA
3-Unit with 100-MW Replacement	17,720,000	$27,643	$8,861	$84,569	-3%
3-Unit with 250-MW Replacement	16,940,000	$26,429	$8,473	$80,837	-7%
2-Unit Operation	12,203,000	$19,036	$6,099	$58,230	NA
2-Unit with 100-MW Replacement	11,683,000	$18,225	$5,842	$55,751	-4%
2-Unit with 250-MW Replacement	10,903,000	$17,010	$5,454	$52,029	-11%

The estimated SCC for the Natural Gas PFR Alternative at a 3 percent discount rate would be between $17,010 million and $27,643 million over the period from 2020 to 2044 (**Table 3.2-12**). At the 5 percent discount rate, the aggregate SCC would range between $5,454 million and $8,861 million, with aggregate SCC or the 95th percentile at a 3 percent discount rate between $52,029 million and $82,569 million. This would be 3 to 11 percent lower than the corresponding values associated with the Proposed Action.

Applying the differences in SCC achieved under the Natural Gas PFR Alternative to the federal share of total emissions would increase the relative changes in SCC achieved. As shown in **Table 3.2-13**, the present value of the SCC associated with those emissions would correspond to between 12 and 29 percent reduction in conjunction with the 3-Unit Operation and between 12 and 30 percent reduction in conjunction with the 2-Unit NGS Operation.

Table 3.2-13 Social Cost of Carbon for the Federal Share of NGS with Natural Gas PFR

NGS Operation	Federal Share of Annual CO_2 Emissions (metric tons)	SCC Present Value for 2020 to 2044 (millions of 2015 USD)		
		Federal Share at 3 Percent	Difference Compared to Proposed Action	Percent Difference
3-Unit Operation	4,432,300	$6,914	NA	NA
3-Unit with 100-MW Replacement	3,912,300	$6,103	$(811)	-12%
3-Unit with 250-MW Replacement	3,132,300	$4,886	$(2,028)	-29%
2-Unit Operation	4,393,100	$6,853	NA	NA
2-Unit with 100-MW Replacement	3,873,100	$6,042	($811)	-12%
2-Unit with 250-MW Replacement	3,093,100	$4,825	($2,028)	-30%

3.2.4.5 Renewable Partial Federal Replacement Alternative

3.2.4.5.1 Emissions

3.2.4.5.1.1 Navajo Generating Station

Under the Renewable PFR Alternative, a selected quantity of power between 100 MW and 250 MW would be contracted for under a long-term power purchase agreement from a currently unidentified, existing renewable energy power source, displacing an equivalent amount of power from the federal share of NGS generation. There would be no emissions associated with the renewable replacement operations; however, the Renewable PFR Alternative assumes that this installation would require firming power generation. See Section 2.2.3 for details regarding firming power. This alternative would require an additional supply of regulation,[3] which is assumed to be 6 percent of each of the renewable generation production levels annually.

The 100-MW to 250-MW replacement design can apply to either the 3-Unit Operation or 2-Unit Operation. GHG emissions from the firming power were based on the emissions that would be associated with a modern combined cycle natural gas fired power plant, with an identical GHG emission rate of 995 lbs. of CO_2 per MW-hour. Similar to the Natural Gas PFR Alternative, the range of emissions under this alternative extends from emissions associated with the 3-Unit Operation with 100-MW replacement power to emissions associated with the 2-Unit Operation with 250-MW replacement power. **Table 3.2-14** provides a tabular summary of GHG emissions from the range of operations. Data are provided for emissions of CO_2e and CO_2 in metric tons. Detailed calculations are provided in **Appendix 3.2-D**. The CO_2 emission data were used in the evaluation of the SCC.

Table 3.2-14 GHG Emissions Associated with the Renewable PFR Alternative

Parameter	3-Unit Operation		2-Unit Operation	
	100-MW Replacement	250-MW Replacement	100-MW Replacement	250-MW Replacement
Annual CO_2e Emissions (metric tons)				
NGS Generation	17,719,000	16,913,000	11,634,000	10,827,000
Firm Power Generation	14,000	35,000	14,000	35,000
NGS Support Operations	130,000	130,000	130,000	130,000
Total Rounded	17,863,000	17,078,000	11,778,000	10,992,000
Annual CO_2 Emissions (metric tons)				
NGS Generation	17,578,000	16,778,000	11,541,000	10,741,000
Firm Power Generation	14,000	35,000	14,000	35,000
NGS Support Operations	129,000	129,000	129,000	129,000
Total Rounded	17,721,000	16,942,000	11,684,000	10,905,000

3.2.4.5.1.2 Proposed Kayenta Mine Complex

Under the Renewable PFR Alternative, the proposed KMC would produce the coal to meet the expected power generation at NGS. For purposes of the analysis of GHG emissions, the changes in coal production were used to estimate the changes in GHG emissions both from methane emissions from coal mine operations and from GHG emissions from equipment operations. **Table 3.2-15** provides total

[3] Regulation refers to backup generating capacity and power that can be supplied very quickly from another source on an "as needed" basis. For this assessment such support is assumed to be supplied by a modern combined cycle natural gas fired power plant.

emission rates for the Natural Gas PFR Alternative from the proposed KMC operations based on the total production of coal.

Table 3.2-15 GHG Emissions from Proposed KMC for the Renewable PFR Alternative

Operation	Proposed KMC Total Coal Production (million tpy)	Emissions (metric tpy in CO_2e)		
		Methane	Equipment	Total [1]
3-Unit Operation	8.1	15,600	65,300	71,000
3-Unit with 100-MW Replacement	7.7	15,200	54,200	69,000
3-Unit with 250-MW Replacement	7.1	14,500	52,500	67,000
2-Unit Operation	5.5	10,600	43,000	54,000
2-Unit with 100-MW Replacement	5.1	10,200	41,900	52,000
2-Unit with 250-MW Replacement	4.5	9,500	40,100	50,000

[1] Data rounded to 1,000.

3.2.4.5.1.3 Transmission Systems and Communication Sites

Except for the GHG emissions from maintenance operations and incidences of on-site emergency power generation (less than 10 metric tons annually), there would be no other GHG emissions associated with the transmission lines and communication sites (**Appendix 3.2-C**, Exhibit 3). The transmission system and communication sites would have no effect on GHG emissions because there would be a very small amount generated during future operation and maintenance. The effects of natural variability in climate conditions would be greater than any projected change in climate conditions related to these operations.

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

No new construction is proposed for the transmission lines and activities along the lines would be limited to routine and periodic major maintenance. Consequently, future climate change effects on these facilities and activities likely would be limited to the increased potential for damage associated with extreme weather events and wildfires, which could require additional maintenance or reconstruction of transmission lines and communication sites. The impacts of such events likely would be localized, short-term, and unpredictable in occurrence and intensity.

3.2.4.5.1.4 Project Impact Summary – All Project Components

The combined GHG emissions from the Renewable PFR Alternative are provided in **Table 3.2-16**. The data show the total emissions from both NGS and proposed KMC as well as a comparison to the total global CO_2e emissions projected for 2040.

Table 3.2-16 Total Project Contribution to Global GHG for Renewable PFR Alternative

Operation	Emissions (tpy in CO_2e)			Fraction of Global CO_2e in 2040
	NGS	Proposed KMC	Total Renewable PFR[1]	
3-Unit Operation	18,387,000	71,000	18,458,000	0.00026
3-Unit with 100-MW Replacement	17,868,000	69,000	17,932,000	0.00026
3-Unit with 250-MW Replacement	17,078,000	67,000	17,145,000	0.00025
2-Unit Operation	12,301,000	54,000	12,355,000	0.00018
2-Unit with 100-MW Replacement	11,778,000	52,000	11,830,000	0.00017
3-Unit with 250-MW Replacement	10,992,000	50,000	11,042,000	0.00016

[1] Data rounded to 1,000.

3.2.4.5.1.5 Cumulative Impacts

Cumulative impacts related to climate change cannot be directly assessed because impacts of GHG emissions are a global issue only. There may be localized cumulative effects on climate, but any conjecture would be purely speculative. The cumulative impacts from the various operations under the Renewable PFR Alternative were compared to the global total cumulative emission estimates during the proposed period of operation. **Table 3.2-17** provides a comparison of the total GHG emissions as a fraction of that total, for the period 2020 through 2044 as well as out to 2050. Global CO_2e emissions would increase by 52 percent from 2020 to 2050, a major impact (**Table 3.2-17**).

Table 3.2-17 Total Renewable PFR Alternative Contribution to Global GHG Emissions

Operation	Fraction of GHG Emissions from PFR Alternative to Global Total			
	2020	2030	2040	2050
3-Unit Operation				
3-Unit with 100-MW Replacement	0.00035	0.00029	0.00026	0.00022
3-Unit with 250-MW Replacement	0.00033	0.00028	0.00025	0.00021
2-Unit Operation				
2-Unit with 100-MW Replacement	0.00023	0.00019	0.00017	0.00015
3-Unit with 100-MW Replacement	0.00021	0.00018	0.00016	0.00014
Global Total CO_2e Emissions (giga-tonne)	52	61	70	80

giga-tonne = 109 metric tonnes = 1,015 g.

3.2.4.5.2 Socioeconomics

Climate change effects on socioeconomic conditions in the study area and in central and southern Arizona under the any configuration of the Renewable PFR Alternative would be minor and the same as the Proposed Action.

3.2.4.5.3 Social Cost of Carbon

Table 3.2-18 displays the estimated NGS SCC over the period from 2020 to 2044 based on the current IWG values (**Table 3.2-2**) for the Renewable PFR Alternative at 3 percent and 5 percent discount rates, as well as for the 95th percentile at 3 percent. The differences in SCC for the Renewable PFR Alternative compared to the corresponding Proposed Action operations also are presented.

The estimated NGS SCC for the Renewable PFR Alternative at a 3 percent discount rate would be between $17,011 million and $27,643 million over the period from 2020 to 2044 (**Table 3.2-18**). At the 5 percent discount rate, the aggregate SCC would range between $5,454 million and $8,861 million, with aggregate SCC for the 95th percentile at a 3 percent discount rate between $52,040 million and $84,569 million. This would be 3 to 11 percent lower than those associated with the Proposed Action.

Table 3.2-18 Social Cost of Carbon for the Renewable PFR Alternative

NGS Operation	Annual CO_2 Emissions (metric tons)	SCC Present Value for 2020 to 2044 (2015 USD)			Difference Compared to the Proposed Action
		At 3% Discount ($ millions)	At 5% Discount ($ millions)	95th Percentile At 3% Discount ($ millions)	
3-Unit Operation	18,240,000	$28,453	$9,121	$87,042	NA
3-Unit with 100-MW Replacement	17,721,000	$27,643	$8,861	$84,569	-3%
3-Unit with 250-MW Replacement	16,942,000	$26,431	$8,473	$80,848	-7%
2-Unit Operation	12,203,000	$19,036	$6,099	$58,230	NA
2-Unit with 100-MW Replacement	11,684,000	$18,228	$5,842	$55,755	-4%
2-Unit with 250-MW Replacement	10,905,000	$17,011	$5,454	$52,040	-11%

Applying the differences in SCC achieved under the Renewable PFR Alternative to the federal share of NGS emissions would increase the relative changes in SCC achieved. As shown in **Table 3.2-19**, the present value of the SCC associated with those emissions correspond to between 12 and 29 percent reduction in conjunction with the 3-Unit Operation and between 12 and 30 percent reduction in conjunction with the 2-Unit Operation.

Table 3.2-19 Social Cost of Carbon for the Federal Share of NGS with Renewable PFR

NGS Operation	Federal Share of Annual CO_2 Emissions (metric tons)	SCC Present Value for 2020 – 2044 (2015 USD)		
		Federal Share at 3 Percent	Difference Compared to Proposed Action	Percent Difference
3-Unit Operation	4,432,300	$6,914	NA	
3-Unit with 100-MW Replacement	3,913,300	$6,104	$(810)	-12%
3-Unit with 250-MW Replacement	3,134,300	$4,889	$(2,025)	-29%
2-Unit Operation	4,393,100	$6,853	NA	NA
2-Unit with 100-MW Replacement	3,874,100	$6,043	$(810)	-12%
2-Unit with 250-MW Replacement	3,095,100	$4,828	$(2,025)	-30%

3.2.4.6 Tribal Partial Federal Replacement Alternative

3.2.4.6.1 Emissions

3.2.4.6.1.1 Navajo Generating Station

Under the Tribal PFR Alternative, between 100 MW and 250 MW of power generation from the NGS would be replaced by power supplied by a new photovoltaic generation facility on tribal land, displacing an equivalent amount of power from the federal share of NGS generation. The Tribal PFR facility would be analyzed in a separate NEPA process once a facility location is identified. Similar to the analysis for the Renewable PFR Alternative, the Tribal PFR Alternative assumes that this installation would require firming power generation. See Section 2.2.3 for details regarding firming power. This alternative also would require regulation, which is assumed to be 6 percent of the renewable generation production levels annually.

The 100-MW to 250-MW peak delivery designs can apply to either the 3-Unit Operation or 2-Unit Operation. GHG emissions from the firming power based on the emissions that would be associated with a modern combined cycle natural gas fired power plant, with a GHG emission rate of 995 pounds of CO_2 per MW-hour. Similar to the Natural Gas and Renewable PFR alternatives, the range of emissions under this alternative extends from emissions associated with the 3-Unit Operation with 100-MW replacement power to emissions associated with the 2-Unit Operation with 250-MW replacement power. **Table 3.2-20** provides a tabular summary of GHG emissions from the range of operations. Data are provided for emissions of CO_2e and CO_2 in metric tons. Detailed calculations are provided in **Appendix 3.2-D**. The CO_2 emission data were used in the evaluation of the SCC.

Table 3.2-20 GHG Emissions Associated with the Tribal PFR Alternative

Parameter	3-Unit Operation		2-Unit Operation	
	100-MW Replacement	250-MW Replacement	100-MW Replacement	250-MW Replacement
Annual CO_2e Emissions (metric tons)				
NGS Generation	17,907,000	17,381,000	11,821,000	11,296,000
Firm Power Generation	9,000	23,000	9,000	23,000
NGS Support Operations	130,000	130,000	130,000	130,000
Total Rounded	18,046,000	17,534,000	11,960,000	11,449,000
Annual CO_2 Emissions (metric tons)				
NGS Generation	17,763,000	17,242,000	11,726,000	11,206,000
Firm Power Generation	9,000	23,000	9,000	23,000
NGS Support Operations	129,000	129,000	129,000	129,000
Total Rounded	17,901,000	17,394,000	11,864,000	11,358,000

3.2.4.6.1.2 Proposed Kayenta Mine Complex

Under the Tribal PFR Alternative, the proposed KMC would produce the coal to meet the expected power generation at NGS. For purposes of the analysis of GHG emissions, the changes in coal production were used to estimate the changes in GHG emissions both from methane emissions from coal mine operations and from GHG emissions from equipment operations. **Table 3.2-21** provides total emission rates for the Natural Gas PFR Alternative from the proposed KMC operations based on the total production of coal.

Table 3.2-21 GHG Emissions from Proposed KMC for the Tribal PFR Alternative

Operation	Proposed KMC Total Coal Production (million tpy)	Emissions (metric tpy in CO_2e)		
		Methane	Equipment	Total [1]
3-Unit Operation	8.1	15,600	55,300	71,000
3-Unit with 100-MW Replacement	7.7	15,300	54,600	70,000
3-Unit with 250-MW Replacement	7.1	14,800	53,500	68,000
2-Unit Operation	5.5	10,600	43,000	54,000
2-Unit with 100-MW Replacement	5.1	10,300	42,300	53,000
2-Unit with 250-MW Replacement	4.5	9,800	41,100	51,000

[1] Data rounded to 1,000.

3.2.4.6.1.3 Transmission Systems and Communication Sites

Except for the GHG emissions from maintenance operations and incidences of on-site emergency power generation (less than 10 metric tons annually), there would be no other GHG emissions associated with the transmission lines and communication sites (**Appendix 3.2-C**, Exhibit 3). The transmission system and communication sites would have no effect on GHG emissions because there would be a very small amount generated during future operation and maintenance. The effects of natural variability in climate conditions would be greater than any projected change in climate conditions related to these operations.

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

No new construction is proposed for the transmission lines and activities along the lines would be limited to routine and periodic major maintenance. Consequently, future climate change effects on these facilities and activities likely would be limited to the increased potential for damage associated with extreme weather events and wildfires, which could require additional maintenance or reconstruction of transmission lines and communication sites. The impacts of such events likely would be localized, short-term, and unpredictable in occurrence and intensity.

3.2.4.6.1.4 Project Impact Summary – All Project Components

The combined GHG emissions from the Tribal PFR Alternative are provided in **Table 3.2-22**. The data show the total emissions from both NGS and proposed KMC as well as a comparison to the total global CO_2e emissions projected for 2040.

Table 3.2-22 Total Project Contribution to Global GHG for Tribal PFR Alternative

Operation	Emissions (tpy in CO_2e)			Fraction of Global CO_2e in 2040
	NGS	Proposed KMC	Total Tribal PFR[1]	
3-Unit Operation	18,387,000	71,000	18,458,000	0.00026
3-Unit with 100-MW Replacement	18,046,000	70,000	18,116,000	0.00026
3-Unit with 250-MW Replacement	17,534,000	68,000	17,602,000	0.00025

Table 3.2-22 Total Project Contribution to Global GHG for Tribal PFR Alternative

Operation	Emissions (tpy in CO_2e)			Fraction of Global CO_2e in 2040
	NGS	Proposed KMC	Total Tribal PFR[1]	
2-Unit Operation	12,301,000	54,000	12,355,000	0.00018
2-Unit with 100-MW Replacement	11,960,000	53,000	12,013,000	0.00017
2-Unit with 250-MW Replacement	11,449,000	51,000	11,500,000	0.00016

[1] Data rounded to 1,000.

3.2.4.6.1.5 Cumulative Impacts

Cumulative impacts related to climate change cannot be directly assessed because impacts of GHG emissions are a global issue only. There may be localized cumulative effects on climate, but any conjecture would be purely speculative. The cumulative impacts from the various operations under the Tribal PFR Alternative were compared to the global total cumulative emission estimates during the proposed period of operation. **Table 3.2-23** provides a comparison of the total GHG emissions as a fraction of that total, for the period 2020 through 2044 as well as out to 2050. Global CO_2e emissions would increase by 52 percent from 2020 to 2050, a major impact (**Table 3.2-23**).

Table 3.2-23 Total Tribal PFR Alternative Contribution to Global GHG Emissions

Operation	Fraction of GHG Emissions from PFR Alternative to Global Total			
	2020	2030	2040	2050
3-Unit Operation				
3-Unit with 100-MW Replacement	0.00035	0.00030	0.00026	0.00023
3-Unit with 250-MW Replacement	0.00034	0.00029	0.00025	0.00022
2-Unit Operation				
2-Unit with 100-MW Replacement	0.00023	0.00020	0.00017	0.00015
2-Unit with 250-MW Replacement	0.00022	0.00019	0.00016	0.00014
Global Total CO_2e Emissions	52	61	70	80

giga-tonne = 109 metric tonnes = 1,015 g.

3.2.4.6.2 Socioeconomics

Climate change impacts on socioeconomic conditions in the study area and in central and southern Arizona under any configuration of the Tribal PFR Alternative would be minor and the same as the Proposed Action.

3.2.4.6.3 Social Cost of Carbon

Table 3.2-24 displays the estimated SCC over the period from2020 to 2044 based on the current IWG values (**Table 3.2-2**) for the Tribal PFR Alternatives at 3 percent and 5 percent discount rates, as well as for the 95th percentile at 3 percent. The differences in SCC for the Tribal PFR Alternative compared to the corresponding Proposed Action operations also are presented.

The estimated SCC for the Tribal PFR alternatives, at a 3 percent discount rate would be between \$17,719 million and \$27,926 million over the period from 2020 to 2044 (**Table 3.2-24**). At the 5 percent discount rate, the aggregate SCC would range between \$5,678 million and \$8,952 million, with aggregate SCC for the 95th percentile at a 3 percent discount rate between \$54,199 million and \$85,423 million. This would be 2 to 7 percent lower than those associated with the Proposed Action.

Table 3.2-24 Social Cost of Carbon for the Tribal PFR Alternative

		SCC Present Value for 2020 to 2044 (2015 USD)			
Operation	Annual CO_2 Emissions (metric tons)	At 3% Discount (\$ millions)	At 5% Discount (\$ millions)	At 3% Discount & 95th Percentile (\$ millions)	Difference Compared to the Proposed Action
3-Unit Operation	18,240,000	\$28,453	\$9,121	\$87,042	NA
3-Unit with 100-MW Replacement	17,901,000	\$27,926	\$8,952	\$85,423	-2%
3-Unit with 250-MW Replacement	17,394,000	\$27,134	\$8,697	\$83,004	-5%
2-Unit Operation	12,203,000	\$19,036	\$6,099	\$58,230	NA
2-Unit with 100-MW Replacement	11,864,000	\$18,508	\$5,934	\$56,616	-3%
2-Unit with 250-MW Replacement	11,358,000	\$17,719	\$5,678	\$54,199	-7%

Applying the differences in SCC achieved under the Tribal PFR Alternative to the federal share of total emissions would increase the relative changes in SCC achieved. As shown in **Table 3.2-25**, the present value of the SCC associated with those emissions would correspond to between 8 and 19 percent reduction in conjunction with the 3-Unit Operation and between 9 and 19 percent reduction in conjunction with the 2-Unit Operation.

Table 3.2-25 Social Cost of Carbon for the Federal Share of NGS with Tribal PFR

		SCC Present Value for 2020 to 2044 (millions of 2015 USD)		
Operation	Federal Share of Annual CO_2 Emissions (metric tons)	Federal Share at 3 Percent (\$ Millions)	Difference Compared to Proposed Action	Percent Difference
3-Unit Operation	4,432,300	\$6,914	NA	
3-Unit with 100-MW Replacement	4,093,300	\$6,385	\$(529)	-8%
3-Unit with 250-MW Replacement	3,586,300	\$5,594	\$(1,320)	-19%
2-Unit Operation	4,393,100	\$6,853	NA	NA
2-Unit with 100-MW Replacement	4,254,100	\$6,324	(\$529)	-9%
2-Unit with 250-MW Replacement	3,548,100	\$5,444	(\$1,318)	-19%

3.2.4.7 No Action

3.2.4.7.1 Emissions

Under the No Action Alternative power product ion at NGS would cease and all associated emissions and impacts from future operations would not occur. Immediately following cessation of operations, there may be site closure and remediation activities that would generate emissions; however, any GHG emissions from such activity likely would be negligible.

For purposes of determining the SCC, the No Action assumed that the NGS Participants would secure power from combined cycle natural gas generation sources. The generation of power by a modern combined cycle natural gas fired power plant could be estimated based on the data for the Bowie Power Plant cited above; however, for such an operation, additional GHG emissions would be attributed to a base load unit, including startup and shutdown emissions. If replaced by a modern combined cycle natural gas fired power plant, an estimated 8.63 million metric tons/year of CO_2 would be emitted by that replacement operation (**Appendix 3.2-E**).

Under the No Action Alternative, all coal production at proposed KMC would cease; and other than remedial activity and efforts associated with decommissioning or shutdown, there would be no GHG emissions from the proposed KMC. Temporary emissions would be associated with reclamation activities until the site has achieved final bond release. Reclamation activities are defined in the approved reclamation plan. Activities would be similar to the overburden handling activities in place for normal operations at the mine. Emissions would be associated with heavy equipment operation engine exhaust, and fugitive dust emissions associated with wind erosion and overburden replacement, including soil transfers, bulldozing, grading, and topsoil replacement. Impacts would be similar to operations under the Proposed Action.

The NGS transmission system is an established part of the western U.S. transmission grid and supports reliability and delivery of power throughout the region, well beyond the power generated by the NGS. Therefore, under the No Action Alternative it is likely that that one, several, or all of the land owners/managers of the transmission line rights-of-way and communication site leases would renew some portion of the facilities to keep the power grid performing as expected.

In the event it is determined that some or all of the transmission systems and communication site ROWs are not renewed, a lengthy study and permitting process would need to occur before any decommissioning is initiated due to the essential and integral nature of these facilities with the western electric grid. As noted in Section 2.3.3, up to 4,826 acres within and alongside the transmission system corridors could be temporarily disturbed if the entirety of the transmission systems and communication sites were decommissioned and removed.

3.2.4.7.2 Socioeconomics

Climate changes effects on socioeconomic conditions in the study area and in central and southern Arizona under the No Action would not differ appreciably from those associated with the Proposed Action. This conclusion reflects the fact that although the No Action would result in lower future emission levels than the Proposed Action, the differences in emissions would represent a very small increment within the context of future global emissions and likely would be too small to materially affect climatic influences in the region.

3.2.4.7.3 Social Cost of Carbon

For purposes of the SCC analysis, No Action assumed that NGS would shut down, and that the NGS participants move to secure power from combined cycle natural gas generation sources. Under this scenario, the CAP would procure only the power needed to operate its system and the closure of NGS would eliminate the opportunity for Reclamation to generate and market surplus power under its current authority.

As described in Section 2.4.1, under the No Action Alternative, the required federal approvals to extend the operations of NGS beyond December 2019 would not be obtained. Decommissioning activities would begin in 2018 with effective shutdown of the plant occurring by the end of 2019. While some minor emissions associated with equipment needed for decommissioning would extend beyond 2019, NGS emissions and the associated SCC would cease at the completion of decommissioning activities. As noted above, this analysis assumes that the NGS Participants would secure replacement power from other, presumably non-coal fired, and likely natural gas fired sources. Carbon emissions for combined cycle natural gas sources are substantially lower than those from coal-fired generation. As a result, annual emissions from such sources are estimated at 8.63 million metric tpy, approximately 47 percent of the emission for the Proposed Action 3-Unit Operation. The corresponding SCC estimates associated with those emissions from 2020 to 2044 (all expressed in 2015 dollars) would be $13,462 million at a 3 percent discount rate, $4,313 million at a 5 percent discount rate, and $41,183 million for the 95th percentile at a 3 percent discount rate (**Table 3.2-26**).

Table 3.2-26 Estimated Social Cost of Carbon for No Action Alternative

NGS Configuration	Annual CO_2 Emissions (metric tons)	SCC Present Value for 2020 to 2044 (2015 USD)		
		At 3% Discount ($ millions)	At 5% Discount ($ millions)	95th Percentile at 3% Discount ($ millions)
3-Unit Operation	18,240,000	$28,453	$9,121	$87,042
2-Unit Operation	12,203,000	$19,036	$6,099	$58,230
No Action [1]	8,630,000	$13,462	$4,313	$41,183

[1] For purposes of comparison, No Action emissions assuming natural gas generation reflect the replacement of the total NGS output and the federal share of output (i.e.,2,250 MW and 547 MW, respectively). However, replacement of the federal share under No Action likely would involve only approximately 300 MW to 350 MW to meet CAP's load requirement.

The annual CO_2 emissions and associated SCC values shown in **Table 3.2-26** would be for the overall project. As part of the SCC assessment for the Proposed Action and action alternatives, those totals are factored by 24.3 percent to focus on the effects of prospective changes in the federal share of emissions from NGS. Such a comparison would not be directly pertinent under No Action because operations of NGS would cease and Central Arizona Water Conservation District would need to secure an alternative source of electrical energy. In other words, there would no longer be a federal share of emissions. However, emissions would likely be associated with energy obtained from another source. Due to the reliability requirements associated with Central Arizona Water Conservation District's energy needs, natural gas generation was assumed for this analysis. Under that assumption, future emissions for the No Action Alternative associated with a comparable quantity of energy as would be derived for the federal share of the Proposed Action operations would reduce emissions and associated SCC over the period from 2020 to 2045 by approximately 53 percent (**Table 3.2-27**).

Table 3.2-27 Estimated Social Cost of Carbon for No Action Alternative Compared to Proposed Action Operations

NGS Configuration	Federal Share of Annual CO_2 Emissions (metric tons)	SCC Present Value for 2020 to 2044, (millions of 2015 USD)
		Federal Share at 3 Percent
3-Unit Operation	4,432,300	$6,914
2-Unit Operation	4,393,100	$6,853
No Action [1]	2,097,100	$3,271

[1] For purposes of comparison, No Action emissions assuming natural gas generation reflect the replacement of the total federal share of output (i.e., 547 MW. However, replacement of the federal share under No Action likely would involve only approximately 300 MW to 350 MW to meet CAP's load requirement.

3.2.5 References

Anderson, B., J. Wang, G. Salvucci, S. Gopal, and S. Islam. 2010. Observed Trends in Summertime Precipitation over the Southwestern United States. Journal of Climate 23:1937-1944.

Arizona Department of Environmental Quality. 2014. Technical Review and Evaluation of Application for Air Quality Permit No. 58787. Bowie Power Station, LLC.

Blaustein, A. R., S. C. Walls, B. A. Bancroft, J. L. Lawler, C. L. Searle, and S. S. Gervasi. 2010. Direct and Indirect Effects of Climate Change on Amphibian Populations. Diversity 2010 2:281-313. Internet website: http://dx.doi.org/10.3390/d2020281. Accessed July 26, 2016.

Cayan, D., M. Tyree, K. E. Kunkel, C. Castro, A. Gershunov, J. Barsugli, A. J. Ray, J. Overpeck, M. Anderson, J. Russell, B. Rajagopalan, I. Rangwala, and P. Duffy. 2013. “Future Climate: Projected Average.” In: *Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment*, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 101-125. A report by the Southwest Climate Alliance. Washington, DC: Island Press.

Central Arizona Water Conservation District (CAWCD). 2015. Shortage Impacts to CAP Priority Pools and Customers. Internet website: http://www.cap-az.com/documents/shortage/Water-Planning-Ops.pdf. Accessed July 2015.

Central Arizona Water Conservation District (CAWCD). 2014. Central Arizona Project, 2015-2015 Biennial Budget. Internet website: http://www.cap-az.com/documents/departments/finance/2014-2015-Biennial-Budget.pdf. Accessed July 2015.

Coconino County 2015a. Water Resources BOS Draft. August 2015.

Coconino County 2015b. Economic Development Commission Draft. July 2015.

Cook, E. R., Woodhouse, C. A., Eakin, C. M., Meko, D. M. and D. W. Stahle. 2004. Long-term Aridity Changes in the Western United States. Science 306(5698):1015-1018. November 2004. American Association for the Advancement of Science, Washington, D.C.

Cooley, M. E., J. W. Harshbarger, J. P. Akers, and W. F. Hardt. 1969. Regional Hydrogeology of the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah. U.S. Geological Survey Professional Paper 521-A, 61 p.

Council on Environmental Quality (CEQ). 2016. Memorandum for Heads of Federal Departments and Agencies. Final Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emission and the Effects of Climate Change in National Environmental Policy Act Reviews. Executive Office of the President, Council on Environmental Quality. August 1, 2016.

Council on Environmental Quality (CEQ). 2014a. Revised Draft Guidance on the Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in NEPA Reviews. Federal Register 79:77802-77831, December 24, 2014.

Council on Environmental Quality (CEQ). 2014b. The Cost of Delaying Action to Stem Climate Change. Internet wbsite: https://www.whitehouse.gov/sites/default/files/docs/the_cost_of_delaying_action_to_stem_climate_change.pdf. Accessed October 2014.

Council on Environmental Quality (CEQ). 1986. Regulations For Implementing the Procedural Provisions of the National Environmental Policy Act - 40 CFR Parts 1500-1508. Internet website: https://ceq.doe.gov/ceq_regulations/regulations.html. Accessed May 21, 2016.

Ficke, A., C. Myrick, and L Hanses, 2007. Potential Impacts of Global Climate Change on Freshwater Fisheries. Reviews in Fish Biology and Fisheries 17:581-613.

Fleishman, E., J. Belnap, N. Cobb, C. A. F. Enquist, K. Ford, G. MacDonald, M. Pellant, T. Schoennagel, L. M. Schmit, M. Schwartz, S. van Drunick, A. L. Westerling, A. Keyser, and R. Lucas. 2013. "Natural Ecosystems." In: *Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment*, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 148-167. A report by the Southwest Climate Alliance. Washington, DC: Island Press.

Frisvold, G. B., L. E. Jackson, J. G. Pritchett, and J. P. Ritten. 2013. Agriculture and Ranching. "Agriculture and Ranching." In: *Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment*, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 218-239. A report by the Southwest Climate Alliance. Washington, DC: Island Press.

Garfin, G. A. Jardine, R. Merideth, M. Black, and S. Leroy, Editors. 2013. Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment. A Report by the Southwest Climate Alliance. Washington, D.C. Island Press.

Gershunov, A., B. Rajagopalan, J. Overpeck, K. Guirguis, D. Cayan, M. Hughes, M. Dettinger, C. Castro, R. E. Schwartz, M. Anderson, A. J. Ray, J. Barsugli, T. Cavazos, and M. Alexander. 2013. "Future Climate: Projected Extremes." In: *Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment*, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 126-147. A report by the Southwest Climate Alliance. Washington, DC: Island Press.

Grantz, K., B. Rajagopalan, M. Clark, and E. A. Zagona, 2007: Seasonal Shifts in the North American Monsoon. Journal of Climate 20:1923-1935. American Meteorological Society. May 2007.

Guido, Z. 2009. Cattle and Climate: Ranching in the Arid Southwest. Southwest Climate Outlook. University of Arizona.

Hereford, R. 2016. Recent Alluvial History of the Southern Colorado Plateau. U.S. Geological Survey, Flagstaff, Arizona. Internet website: http://gec.cr.usgs.gov/projects/sw/previous/scpalluvial/ Accessed July 21, 2016

Hereford, R. 1989. Variation of Warm-Season Rainfall Frequency in the Southern Colorado Plateau and its Effect on Runoff and Alluvial-Channel Morphology: A Preliminary Analysis. U.S. Geological Survey Open-file Report 89-330. U.S. Geological Survey, Flagstaff, Arizona.

Hereford, R., Bennett, G. E., and H. C. Fairley. 2014. Precipitation Variability of the Grand Canyon Region, 1893 through 2009, and its Implications for Studying Effects of Gullying of Holocene Terraces and Associated Archeological Sites in Grand Canyon, Arizona. U.S. Geological Survey Open-file Report 2014-1006, 23 p., http://dx.doi/org/10.3133/ofr20141006.

Hoerling, M. P., M. Dettinger, K. Wolter, J. Lukas, J. Eischeid, R. Nemani, B. Liebmann, and K. E. Kunkel. 2013. "Present Weather and Climate: Evolving Conditions" In: *Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate*

Assessment, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 74-100. A report by the Southwest Climate Alliance. Washington, DC: Island Press.

Intergovernmental Panel on Climate Change (IPCC). 2014a. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, and L. L. White, editors). Cambridge University Press, Cambridge, United Kingdom and New York, New York, USA. 1132 pp.

Intergovernmental Panel on Climate Change (IPCC). 2014b. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (V. R. Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, K. J. Mach, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, and L. L. White, editors). Cambridge University Press, Cambridge, United Kingdom and New York, New York, USA. 688 pp.

Intergovernmental Panel on Climate Change (IPCC). 2014c. Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx [eds.]). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Intergovernmental Panel on Climate Change (IPCC). 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (T. F. Stocker, D. Quin, G. K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P. M. Midgley, editors). Cambridge University Press, Cambridge, United Kingdom and New York, New York, USA. 1,535 pp.

Interagency Working Group on Social Cost of Carbon (IWG on Social Cost of Carbon Cost). 2015. Interagency Working Group on Social Cost of Carbon, United States Government. Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866. May 2013 – Revised July 2015. Internet website: https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf. Accessed May 21, 2016.

Interagency Working Group on Social Cost of Carbon (IWG on Social Cost of Carbon Cost). 2013. Interagency Working Group on Social Cost of Carbon, United States Government. Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866. May 2013. Internet website: https://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf. Accessed May 21, 2016.

Interagency Working Group on Social Cost of Carbon (IWG on Social Cost of Carbon Cost). 2010. Interagency Working Group on Social Cost of Carbon, United States Government. Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866. February 2010. Internet website: https://www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf Accessed May 21, 2016.

Karlstrom, T. N. V. 1988. Alluvial Chronology and Hydrologic Change of Black Mesa and Nearby Regions. Pages 45-91 In: The Anasazi in a Changing Environment, G. J. Gumerman (editor). A School of American Research Book, Cambridge University Press, New York, New York. ISBN 0 521 34631 2.

Kirchgessner, D. A., S. D. Piccot, and S. S. Masemore. 2000. An Improved Inventory of Methane Emissions from Coal Mining in the United States. Journal of the Air & Waste Management Association 50:1904-1919.

Loomis, J. B. 2000. Economic Values of Wilderness Recreation and Passive Use: What We Think We Know at the Beginning of the 21st Century. U.S. Department of Agriculture Forest Service Proceedings. RMRS-P-VOL-2.

National Science and Technology Committee (NSTC). 2008. Scientific Assessment of the Effects of Global Change on the United States, A Report of the Committee on Environment and Natural Resources. http://www.globalchange.gov/browse/reports/scientific-assessment-effects-global-change-united-states. Accessed October 2014.

Navajo County. 2011. Navajo County Approved Comprehensive Plan. As approved and adopted by the Navajo County Board of Supervisors. May 24, 2011.

Navajo Tourism Department. 2015. 2015-2019 Navajo Tourism Strategic Plan. Navajo Nation Rising: Capitalizing on Tourism for Economic Development. March 2015.

Navajo Tribal Utility Authority. 2015. Navajo Tribal Utility Authority – About Us. Internet website: http://www.ntua.com/aboutus.html. Accessed July 11, 2016.

Office of Management and Budget (OMB). 2014. Regarding: Request for Correction on the Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866 (February 2010) and Technical Support Document Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866 (May 2013).

Organisation for Economic Cooperation and Development (OECD). 2011. OECD Environmental Outlook to 2050. Climate Change Chapter.

Overpeck, J., G. Garfin, A. Jardine, D. E. Busch, D. Cayan, M. Dettinger, E. Fleishman, A. Gershunov, G. MacDonald, K. T. Redmond, W. R. Travis, and B. Udall. 2013. "Summary for Decision Makers." In: *Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment*, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 1-20. A report by the Southwest Climate Alliance. Washington, DC: Island Press.

Peterson, T. C., R. R. Heim, Jr., R. Hirsch, D. P. Kaiser, H. Brooks, N. S. Diffenbaugh, R. M. Dole, J. P. Giovannett, K. Guirguis, T. R. Karl, R. W. Katz, K. Kunkel, D. Lettenmaier, G. J. McCabe, C. J. Paciorek, K. R. Ryberg, S. Schubert, V. B. S. Silva, B. C. Stewart, A. V. Vecchia, G. Villarini, R. S. Vose, J. Walsh, M. Wehner, D. Wolock , K. Wolter, C. A. Woodhouse, and D. Wuebbles. 2013. Monitoring and Understanding Changes in Heat Waves, Cold Waves, Floods, and Droughts in the United States: State of knowledge. Bulletin of the American Meteorological Society 94:821-834.

Pincetl, S., G. Franco, N. B. Grimm, T. S. Hogue, S. Hughes, E. Pardyjak, A. M. Kinoshita, and P. Jantz. 2013. "Urban Areas." In: *Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment*, edited by G. Garfin, A. Jardine,

R. Merideth, M. Black, and S. LeRoy, 267-296. A report by the Southwest Climate Alliance. Washington, DC: Island Press.

Redsteer, M. H. K. B. Kelley, H. Francis, and D. Block. 2015. Increasing Vulnerability of the Navajo People to Drought and Climate Change in the Southwestern United States: Accounts from Tribal Elders. In: Indigenous Knowledge for Climate Change Assessment and Adaptation: Part 3 Facing Extreme Events. D. Nakashima, J. Rubis, and U. Krupnik, editors. Cambridge University Press.

Redsteer, M. H., K. Bemis, K. Chief, M. Gautam, B. R. Middleton, and R. Tsosie. 2013. "Unique challenges Facing Southwestern Tribes." In: *Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment*, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 385-404. A report by the Southwest Climate Alliance. Washington, DC: Island Press.

Redsteer, M., K. Kelley, H. Francis, and D. Block. 2010. Disaster Risk Assessment Case Study: Recent Drought on the Navajo Nation, Southwestern United States. United Nations Global Assessment Report 2011.

Rhoades, E. K. 2013. The Hopi People and Drought: Observations, Adaptations, and Stewardship in a Sacred Land. A dissertation submitted to Johns Hopkins University in conformity with the requirements for the degree of Doctor of Philosophy.

Rose, S. K., D. Turner, G. Blanford, J. Bistline, F. de la Chesnaye, and T. Wilson. 2014. Understanding the Social Cost of Carbon: A Technical Assessment. EPRI, Palo Alto, California. Report #3002004657.

Seidman Institute. 2014. The Economic Impact of the Central Arizona Project to the State of Arizona. Tempe: Arizona State University, W. P. Carey School of Business, L. William Seidman Research Institute.

Settele, J., R. Scholes, R. Betts, S. Bunn, P. Leadley, D. Nepstad, J. T. Overpeck, and M. A. Taboada. 2014. Terrestrial and Inland Water Systems. Pages 271-359 In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, and L. L. White, editors). Cambridge University Press, Cambridge, United Kingdom and New York, New York, USA.

Statista 2016 Energy-Related Global CO_2 Emissions from 1990 to 2040, by Fuel. Internet website: http://www.statista.com/statistics/242204/energy-related-global-co2-emissions-by-fuel/. Accessed July 27, 2016.

Stocker, T. F., D. Qin, G. K. Plattner, L. V. Alexander, S. K. Allen, N. L. Bindoff, F. M. Bréon, J. A. Church, U. Cubasch, S. Emori, P. Forster, P. Friedlingstein, N. Gillett, J. M. Gregory, D. L. Hartmann, E. Jansen, B. Kirtman, R. Knutti, K. Krishna Kumar, P. Lemke, J. Marotzke, V. Masson-Delmotte, G. A. Meehl, I. I. Mokhov, S. Piao, V. Ramaswamy, D. Randall, M. Rhein, M. Rojas, C. Sabine, D. Shindell, L. D. Talley, D. G. Vaughan, and S.-P. Xie. 2013. Technical Summary. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (T. F. Stocker, D. Qin, G. K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P. M. Midgley, editors). University Press, Cambridge, United Kingdom and New York, New York, USA.

Tidwell, V. C., L. Dale, G. Franco, K. Averyt, M. Wei, D. M. Kammen, and J. H. Nelson. 2013. “Energy: Supply, Demand, and Impacts.” In *Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment*, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 240–266. A report by the Southwest Climate Alliance. Washington, DC: Island Press.

Thornthwaite, C. W., C. F. Stewart Sharpe, and E. F. Dosch. 1942. Climate and Accelerated Erosion in the Arid and Semi-Arid Southwest with Special Reference to the Polacca Wash Drainage Basin, Arizona. United States Department of Agriculture Technical Bulletin No. 808, May 1942. Internet website: http://ageconsearch.umn.edu/bitstream/169148/2/tb808.pdf. Accessed June 16, 2016.

Udall, B. 2013. Water: Impacts, Risks, and Adaptation. In: Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy. A report by the Southwest Climate Alliance. Washington, D.C. Island Press.

U.S. Bureau of Economic Analysis (BEA). 2014. CA 25 Total Full Time and Part Time Employment by Industry (CA25). Internet website: http://www.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=5#. Accessed May 21, 2016.

U.S. Bureau of Labor Statistics (BLS). 2016. Consumer Price Index – Urban Wage Earners and Clerical Workers, 2007 – 2015, 1982 – 1984 – 100.

U.S. Bureau of Reclamation. 2016. SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water. Prepared for United States Congress. Denver, CO: Bureau of Reclamation, Policy and Administration.

U.S. Bureau of Reclamation (Reclamation). 2014. Climate Change Adaptation Strategy. Reclamation: Managing Water in the West. November 2014. http://www.usbr.gov/climate/docs/ClimateChangeAdaptationStrategy.pdf

U.S. Bureau of Reclamation (Reclamation). 2012. Colorado River Basin Water Supply and Demand Study Report. December 2012. 85 pp.

U.S. Bureau of Reclamation (Reclamation). 2005. Water 2025: Preventing Crises and Conflict in the West. Water 2025 Status Report. Internet website: http://permanent.access.gpo.gov/lps77383/Water%202025-08-05.pdf. Accessed May 21, 2016.

U.S. Department of the Interior (DOI). 2016. Climate Change. Internet website: https://www.doi.gov/climate. Accessed May 24, 2014.

U.S. Environmental Protection Agency (USEPA). 2015. U.S. Greenhouse Gas Inventory Report: 1990-2014. EPA 430-R-15-004 USEPA Washington, D.C. Internet website: http://www.epa.gov/climatechange/emissions/usinventoryreport.html . Accessed May 21, 2016.

U.S. Geological Survey (USGS). 2004. National Gap Analysis Program. Provisional Digital Land Cover Map for the Southwestern United States. Southwest Regional GAP Analysis Project Data. Version 1.0. RS/GIS Laboratory, College of Natural Resources, Utah State University.

Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, S. Doney, R. Feely, P. Hennon, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville. 2014. Chapter 2 In: Our Changing Climate. Climate

Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, T. C. Richmond, and G. W. Yohe, editors. U.S. Global Change Research Program, 19-67. Internet website: http://nca2014.globalchange.gov/report/our-changing-climate/introduction. Accessed May 21, 2016.

Webb, R. H. and R. Hereford. 2001. Floods and Geomorphic Change in the Southwestern United States: An Historical Perspective. pp IV-30 – IV-37, in: Proceedings of the Seventh Federal Interagency Sedimentation Conference, March 25-29, 2001. Reno, NV. Internet website: http://gec.cr.usgs.gov/projects/sw/previous/pubs/task6/Webb_and_Hereford_2001.pdf Accessed July 21, 2016.

Western Regional Climate Center (WRCC). 2014. Climate of Arizona. Internet website: http://www.wrcc.dri.edu/summary/Climsmaz.html Accessed May 21, 2016.

Zhu, C. and R. Kipfer. 2010. Noble Gas Signatures of High Recharge Pulses and Migrating Jet Stream in the Late Pleistocene over Black Mesa, Arizona, United States. Geology 38:3-6.

Zhu C., R. K. Waddel, Jr., I. Star, and M. Ostrander. 1998. Responses of Ground Water in the Black Mesa Basin, Northeastern Arizona, to Paleoclimatic Changes during the Late Pleistocene and Holocene. Geology 26(2):127-130. February 1998.

Section 3.3

Geology and Landforms

Acronyms and Abbreviations

1969 Lease	Navajo Project Indenture of Lease
BART	Best Available Retrofit Technology
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BM&LP Railroad	Black Mesa & Lake Powell Railroad
BO	Biological Opinion
CAP	Central Arizona Project
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO_2	carbon dioxide
Co-tenants	Salt River Project, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company
Development Fund	Lower Colorado River Basin Development Fund
EIS	Environmental Impact Statement
ERA	Ecological Risk Assessment
ESA	Endangered Species Act of 1973
HHRA	Human Health Risk Assessment
km	kilometer
KMC	Kayenta Mine Complex
kV	kilovolt
kW	kilowatt
MW	megawatt
N-Aquifer	Navajo Aquifer
NEPA	National Environmental Policy Act of 1969, as amended
NGS	Navajo Generating Station
NGS Participants	U.S. (Reclamation), Salt River Project, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company
NHPA	National Historic Preservation Act
NNEPA	Navajo Nation Environmental Protection Agency
NO_2	nitrogen dioxide
NO_X	nitrogen oxide
OSMRE	Office of Surface Mining Reclamation and Enforcement
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter of 10 microns or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 microns or less
PFR	Partial Federal Replacement
PWCC	Peabody Western Coal Company
Reclamation	Bureau of Reclamation
ROW	Right-of-way

SO_2	sulfur dioxide
SRP	Salt River Project Agricultural Improvement and Power District
STS	Southern Transportation System
tpy	tons per year
U.S.	United States
USEPA	U.S. Environmental Protection Agency
WTS	Western Transportation System

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3.3 Geology and Landforms

3.3.1 Regulatory Framework

Federal laws which protect unique geologic features include the National Environmental Policy Act (NEPA), National Forest Management Act of 1976, National Park Service Organic Act, National Wild and Scenic Rivers Act, and Federal Land Policy and Management Act.

The Arizona Geologic Survey is tasked under Arizona Revised Statutes to catalog and archive data on the location of earth fissures (Allison and Shipman 2007). Utah and Nevada do not have similar state laws regarding geologic hazards.

3.3.2 Study Areas

3.3.2.1 Proposed Action and Action Alternatives

The study area for geology and landforms includes the Navajo Generating Station (NGS) and associated facilities, and the proposed Kayenta Mine Complex (KMC). Associated facilities of the NGS include the Black Mesa & Lake Powell (BM&LP) Railroad right-of-way (ROW) that extends from the proposed KMC to the NGS (**Figure 3.3-1**). Associated facilities of the NGS also include the coal combustion residuals disposal site, lake pumping station, water pipeline, a 230-kilovolt (kV) electrical transmission line, powerlines from the pump station to the NGS, the road between Navajo Nation Route 22B and the pump station, and the coal loadout facility (**Table 1-2, Figure 1-3**). In addition, the study area extends along the maintained transmission system corridor ROWs and communication sites.

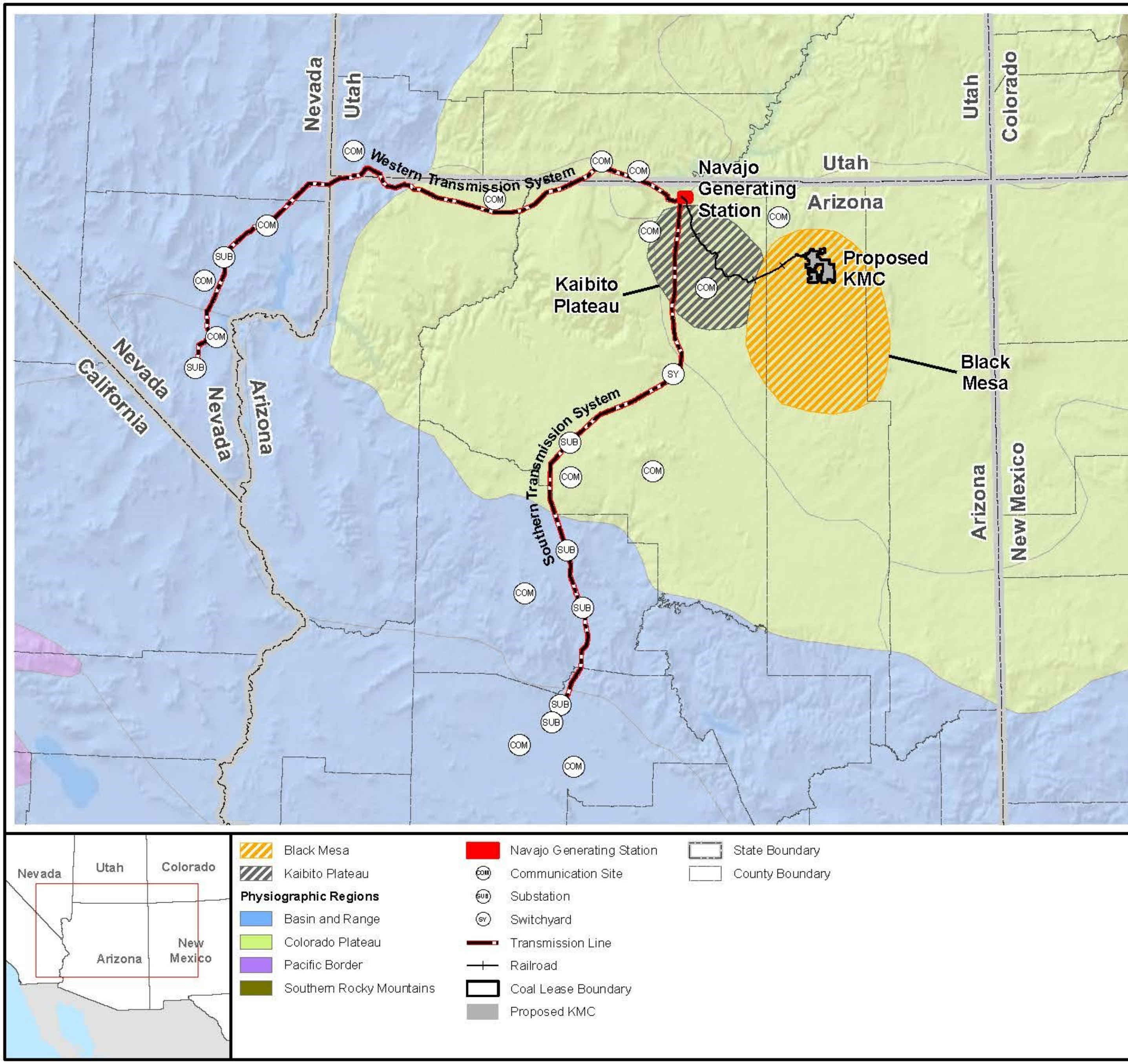
3.3.2.2 Cumulative

The cumulative effects study area is the same as the study area because direct and indirect effects due to the proposed project are not likely to combine with other effects beyond the Proposed Action study area.

3.3.3 Affected Environment

The NGS facilities are located in the Colorado Plateau physiographic province which is typified by gently dipping sedimentary strata that have been sculpted by erosion to form mesas and plateaus (**Figure 3.3-1**). In addition to sedimentary rock, there are areas of igneous rocks. The major physiographic features in the analysis area are the Black Mesa and the Kaibito Plateau (Trapp and Reynolds 1995). Unconsolidated surficial deposits consist of alluvium and sand dunes (Billingsley and Priest 2013). No unusual or unique geologic features were identified.

The Black Mesa is a physiographic feature that is part of a Laramide structural basin referred to as the Black Mesa Basin (Nations et al. 2000). The physiographic mesa is composed of Upper Cretaceous rocks. The mesa is roughly 60 miles long and 50 miles wide and is bounded by steep escarpments and cliffs on the northeast and northwest sides with elevations ranging from 6,000 feet above mean sea level on the southwest side to 8,000 feet above mean sea level on the northeast side. The Kayenta Mine is located on the north end of Black Mesa.



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 3.3-1 Physiography and Project Components

0 10 20 30 60 90 Miles
0 10 20 30 60 90 Kilometers
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The Kaibito Plateau is a low relief feature that extends from the Page, Arizona, area to the Black Mesa. The Kaibito Plateau trends northwest to southeast and is approximately 50 miles long and 25 miles wide. Elevations of the Kaibito Plateau range from approximately 3,900 feet above mean sea level at Lake Powell to almost 7,000 feet above mean sea level at the south end of the plateau. Most of the relief is on the west side of the plateau where the Echo Cliffs form the western boundary of the plateau (Wanek and Stephens 1953). The bedrock on the Kaibito Plateau primarily is the Jurassic Navajo Sandstone, Page Sandstone, and the Carmel Formation, but also exposed on the east side of the plateau is the Jurassic Entrada Sandstone. Structurally, the plateau is a syncline referred to as the Kaibito Saddle or Basin and is part of a larger synclinal structure that includes the Black Mesa Basin and extends northwestward to the Kaiparowits Basin in Utah (Kelley 1958; Nations et al. 2000).

In the study areas there are rocks ranging in age from Precambrian to Holocene. **Figures 3.3-2** and **3.3-3** show the geologic units that outcrop in the vicinity of the NGS and proposed KMC. Older Paleozoic and Precambrian rocks are not shown in these figures because they are buried too deep and are not exposed on the surface in this area and therefore, are not relevant to this analysis. Tertiary rocks generally are absent with a few exceptions and it is believed that the Tertiary formations were eroded during regional uplift that occurred in late Tertiary (Cooley et al. 1969). Tertiary rocks that are present consist of conglomerate, sandstone, mudstone, siltstone, and gypsum (Arizona Geological Survey 2015a). Erosion during the Tertiary also removed a large amount of Cretaceous and Jurassic rocks. The Black Mesa is an erosional remnant of Cretaceous rocks that were not removed.

Within both the Kaibito and Black Mesa Basins are small scale folds that generally trend northwest to southeast. There are a few faults mapped in exposed bedrock that trend either northwest-to-southeast or northeast-to-southwest. No Quaternary or potentially active faults have been identified in the Black Mesa or Kaibito Plateau (U.S. Geological Survey and Arizona Geological Survey 2006). A fault is considered active if movement can be determined in the last 10,000 years (Holocene epoch) (U.S. Geological Survey 2012). Seismic activity in the area generally is low. An earthquake catalog search indicated that within a search radius of 100 miles of the NGS-KMC area, there were 82 events since 1973. Of these events, 81 were less than 4.0 magnitude. Only one event measured 4.0 on the Richter Scale (U.S. Geological Survey 2015). There is a low probability of strong ground motion if a maximum credible earthquake were to occur in the vicinity. Horizontal ground motions are expected to be less than 16 percent of the acceleration gravity with a 2 percent probability of exceedance in 50 years or there is a 2 percent chance of exceedance of the highest horizontal acceleration shown on the seismic hazards map or a 98 percent probability that a given area would not experience one exceedance of the maximum acceleration in 50 years or once in 2,475 years (Petersen et al. 2015).

Landslides are common in the Colorado Plateau area and generally occur as a result of erosional undercutting of resistant layers of rocks that cap mesas and plateaus and which are underlain by material that is more easily eroded than the cap rock (Radbruch-Hall et al. 1982). Block-landslides that are present along the sides and bases of mesas and plateaus are indicative of a high incidence of landslides in these areas. Medium- to high-incidence areas are present along the perimeter of the Black Mesa where blocks of sandstone have slid down the sides of the mesa (Conway 2014). Also, the Black Mesa is the location of a particular kind of large mass-movement of rock and soil that is called a Toreva-Block. This type of movement occurs when a large, single mass of material rotates backwards (towards the cliff) as it falls (Reiche 1937). Toreva-Block slides are present on the south side of Black Mesa and the slides are named after proximity to the Town of Toreva, Arizona, and involve rocks of the Mesaverde and Mancos formations. The slides are very large, up to 2,000 feet in length and 500 or more feet in width. Large slides are located 4 miles north of Blue Gap where blocks of Toreva Formation have collapsed where the underlying Mancos Shale was probably eroded. Blue Gap is located about 30 miles southeast of the Kayenta Mine.

System	Series	Group	Formation / Unit		Description
Neoggene	Miocene-Holocene		No formal unit names		Unconsolidated deposits including alluvium, dunes, and terraces composed of gravel, sand, silt, and clay. Includes igneous rocks (basalt and andesite).
Cretaceous	Upper Cretaceous	Mesaverde	Yale Point Sandstone		Consists mainly of sandstone, present only at northeast edge of Black Mesa, 200 feet thick.
			Wepo Formation	Upper Member	Both members are composed of primarily of coal, carbonaceous siltstone, and mudstone, and tabular and lenticular sandstone bodies, 200 to 400 feet thick. The members are separated in part by the tongues of the Rough Rock Sandstone of the Mesaverde Group and the Wind Rock Mancos Formation.
				Lower Member	
			Toreva Formation	Upper Member	Coarse sandstone, 25-120 feet thick.
				Middle Member	Carbonaceous siltstones, mudstones, coal, and sandstones; zero to 100 feet thick.
				Lower Member	Fine- to medium grained sandstone, 100 feet thick.
			Mancos Shale		Siltstone and claystone, 475 to 700 feet thick.
			Dakota Formation	Upper Member	Fine-grained sandstone, thickness variable and uncertain.
				Middle Member	Carbonaceous siltstone and coal, 20 to 40 feet thick.
				Lower Member	Medium- to fine-grained sandstone, 30 to 60 feet thick.
Jurassic	Upper Jurassic		Morrison Formation		Sandstone and siltstone, 200 to 600 feet thick
	Middle Jurassic		Wanakah Formation / Cow Springs Sandstone		Sandstone, siltstone, and minor limestone, 180 feet thick.
		San Rafael Group	Entrada Sandstone		Sandstone, minor siltstone, up to 785 feet thick
			Carmel Formation		Siltstone, claystone, and silty calcareous and gypsiferous sandstone, 160 to 240 feet thick.
			Page Sandstone		Fine- to medium-grained sandstone, with thin siltstone. Unconformably overlies similar-appearing Navajo Sandstone east, south, and southwest of Glen Canyon Dam, zero to 300 feet thick.
	Lower Jurassic	Glen Canyon Group	Navajo Sandstone		Fine- to medium grained well sorted sandstone, prominent cliff former; 1,200 to 1,750 feet thick.
			Kayenta Formation (Springdale Sandstone Member)		Fine- to medium-grained sandstone and mudstone, siltstone, and silty sandstone; 240 to 300 feet thick.
			Moenave / Wingate Sandstone		Coarse-grained fluvial siltstones and silty sandstones; 80 to 140 feet thick.
Triassic	Upper Triassic		Chinle Formation		Coarse- to fine-grained sandstone, siltstone, mudstone, and limestone, up to 900 feet thick.
	Lower - Middle Triassic		Moenkopi Formation		Limestone, mudstone, siltstone, coarse grained and conglomeratic sandstone, up to 620 feet.
Permian			Kaibab Formation		Limestone, dolomite, calcareous sandstone, siltstone, 350 feet thick.
			Toroweap Formation		Siltstone, calcareous sandstone, gypsum, limestone and dolomite, up to 220 feet thick.
			Coconino Sandstone		White, cliff-forming quartz sandstone, up to 400 feet thick.
Pennsylvanian			Supai Group		Cliff-forming sandstone, siltstone, mudstone, 825 feet thick.

Sources: Allis et al. 2003; Arizona Geological Survey 2015a; Billingsley and Priest 2013, Condon and Huffman 1988; Cooley et al. 1969; Franczyk 1988; Hintze, 1988; Nations et al. 2000; Peterson and Pipiringos, 1979.

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 3.3-2

Stratigraphic Chart

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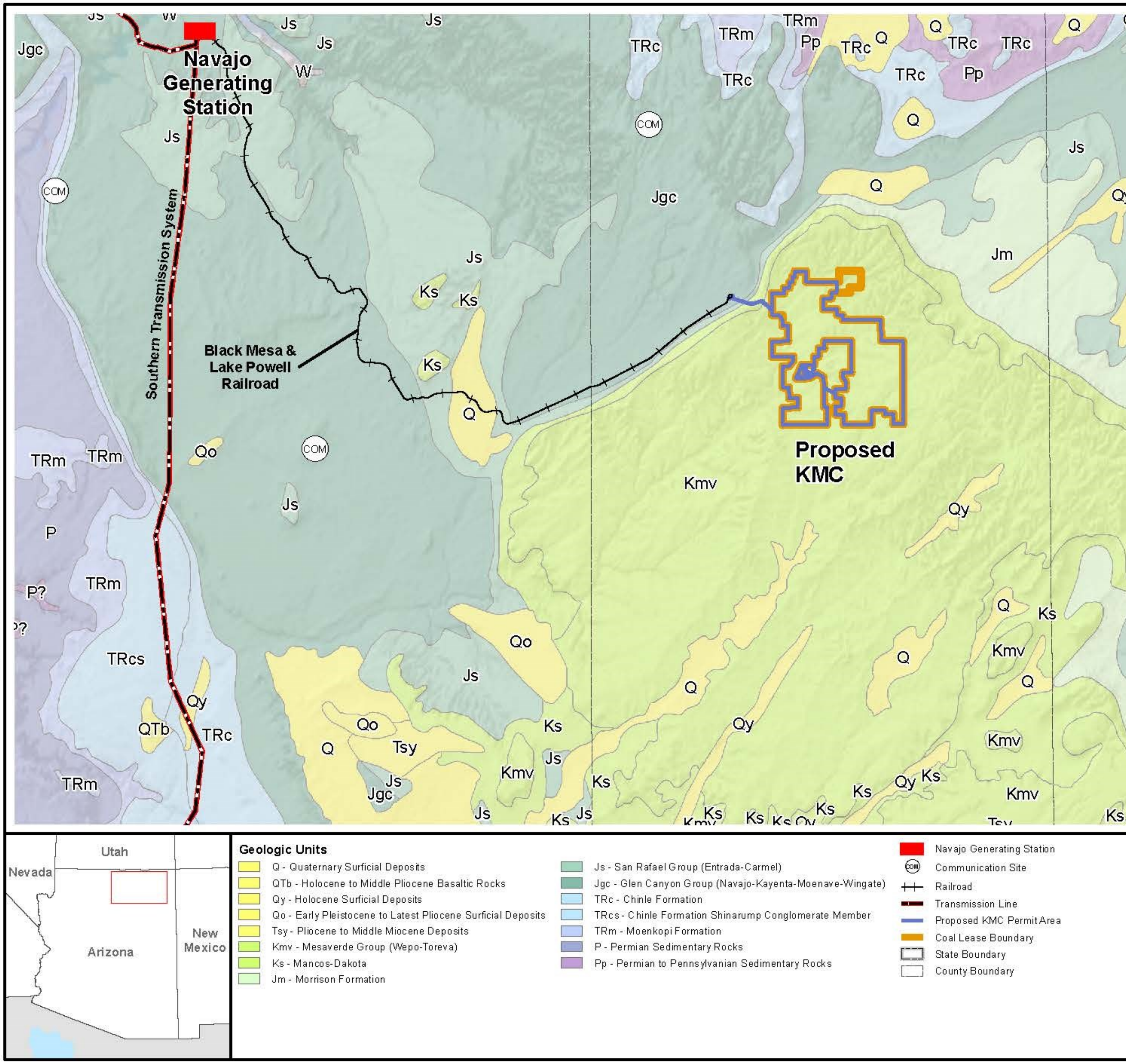

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 3.3-3 Surficial Geology

0 5 10 15 Miles
0 5 10 15 Kilometers
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Cracks and sinkholes have been identified at several locations at Black Mesa and likely are attributed to prolonged drought resulting in large desiccation cracks that have been further eroded during precipitation events. According to the Office of Surface Mining Reclamation and Enforcement (OSMRE [2011]), "In 2003 land subsidence features in the form of sinkholes, cracks, and slumps were reported near Forest Lake, about 7 miles south of the Peabody Western Coal Company (PWCC) lease area. After investigation by Office of Surface Mining, Navajo Nation Minerals Department, Navajo Nation Water Resources Department, and U.S. Geological Survey, all of the subsidence features of concern were determined to be either in or adjacent to unconsolidated alluvial valley deposits and due to surface water entering and eroding desiccation features following an extended period of drought. These features are unrelated to the mining or water production facilities on the PWCC lease area. Subsidence and formation of sinkholes in the Navajo Aquifer (N-Aquifer) well field area is considered highly unlikely."

The transmission systems and communication sites are located in the Colorado Plateau and Basin and Range physiographic provinces (**Figure 3.3-1**) (Fenneman 1928). The Basin and Range province is characterized by isolated, block-faulted mountain ranges interspersed among basins or valleys. When the mountains were uplifted during the Tertiary, erosion caused sediment to be shed from the mountains and deposited in the valleys. The mountain ranges generally are oriented northwest-to-southeast and parallel to each other. On the south side of the Colorado Plateau in Arizona there is a transitional area that exhibits characteristics of both provinces such as areas of flat-lying sedimentary rocks and faulted mountain ranges (Rasmussen 2012). The transmission line corridors cross a variety of geologic units from Precambrian to Holocene. Quaternary faults are common in the analysis area, but only a few are considered active. The potential for earthquake-generated ground motion in the analysis area ranges from moderate to low (Petersen et al. 2015). Other geologic hazards that could potentially affect the project facilities are landslides and fissures. The landslide hazard occurs where large slumps and slides can occur along the sides of mesas and escarpments. Fissures occur where extensive groundwater pumping causes subsidence of unconsolidated valley fill materials (Arizona Geological Survey 2015b). Earth fissures would only be expected to affect the most southerly portions of the transmission line corridors in the Phoenix area.

3.3.3.1 Navajo Generating Station

The NGS is located on the northern end of the Kaibito Plateau and the bedrock at the site is composed of the Navajo Sandstone, the Page Sandstone, and the Carmel Formation (Allis et al. 2003; Billingsley and Priest 2013).The Navajo Sandstone, which is Lower Jurassic in age, is part of the Glen Canyon Group that is composed of the Navajo Sandstone, Kayenta Formation, and the Moenave/Wingate Sandstone (**Figure 3.3-2**). The Navajo Sandstone primarily is composed of fine- to medium-grained quartz sandstone and is regionally widespread. The Navajo Sandstone and its equivalents have been identified from southern Nevada, northern Arizona, much of Utah, western Colorado, southern Wyoming, and southeastern Idaho, covering an area of approximately 97,000 square miles (Tape 2005). The Navajo Sandstone was derived from wind-driven sand and is known for its characteristics as a prominent cliff former, large-scale cross bedding, and pale-red and white sandstone. The Navajo Sandstone is reported to be 1,400 feet thick in the NGS facility area and 1,750 feet thick where the Navajo Sandstone is exposed in the walls of the Echo Cliffs on the west side of Kaibito Plateau (Billingsley and Priest 2013).

The Page Sandstone is the lowest member of the San Rafael Group that also is composed of (in ascending order) the Carmel Formation and the Entrada Sandstone (**Figure 3.3-2**). The Page Sandstone looks very similar to and was considered part of the Navajo Sandstone until it was determined that the units are separated by a major regional Jurassic unconformity and that deposition was not continuous from the Navajo Sandstone to the Page Sandstone (Peterson and Pipiringos 1979). The Page Sandstone is very limited in extent and is found in north-central Arizona and south-central Utah. The Page Sandstone is up to 300 feet thick 8 miles south of Page, Arizona, where it is exposed along the Echo Cliffs (Billingsley and Priest 2013). However the Page Sandstone thins rapidly in all directions and occurs as erosional remnants on the Kaibito Plateau, varying from 125 to 250 feet in the vicinity of NGS (Pipiringos and O'Sullivan 1978). The Page sandstone underlies portions of the NGS and facilities, with the plant itself underlain by the Carmel Formation. The coal combustion residuals disposal site, the water pipeline, and the 230-kV electrical transmission line from the pump station to the NGS are located on the Page Sandstone and the Navajo Sandstone (Billingsley and Priest 2013). The lake pumping station and the road between Navajo Nation Route 22B and the pump station are located on the Navajo Sandstone. The coal unloading and storage facilities are located on the Carmel Formation.

The Carmel Formation is composed of siltstone, claystone, and silty calcareous and gypsiferous sandstone, 160 to 240 feet thick (Billingsley and Priest 2013; Wanek and Stephens 1953). It is distinguished from the Navajo and Page Sandstones by its reddish-brown color. The Page Sandstone and Carmel Formation are erosional remnants that form benches on the Navajo Sandstone. The plant site and coal combustion residuals disposal site are located on these benches formed by the Page Sandstone and Carmel Formation. The Carmel Formation is reported to be less than 70 feet thick in the vicinity of NGS (Salt River Project Agricultural Improvement and Power District 2016). The contrast with the reported regional thickness of the Carmel is indicative of possible erosion that has thinned the unit.

From the coal loadout facility heading southwest, the BM&LP Railroad crosses the Klethia Valley that is located between Black Mesa on the southeast and the White and Shonto mesas to the northwest. The Klethia Valley is the location of the Cow Creek Syncline, a trough fold that separates the Black Mesa from the plateaus to the northwest (Nations et al. 2000; Trapp and Reynolds 1995). The train route through the Klethia Valley crosses unconsolidated sand dune deposits and bedrock of the San Raphael and Glen Canyon Groups (Haynes and Hackman 1978). Twenty miles from the loadout, the railroad turns to the northwest and crosses onto the Kaibito Plateau where the route is largely underlain by the Navajo Sandstone until about 10 miles south of the NGS site where the railroad crosses the Carmel Formation to its terminus at the power plant (Billingsley and Priest 2013). Surficial deposits crossed on the Kaibito Plateau consist mainly of sand dunes.

3.3.3.2 Proposed Kayenta Mine Complex

The bedrock at the proposed KMC consists of the upper Cretaceous Dakota Formation, Mancos Shale, and the Mesaverde Group. The Dakota Formation is the stratigraphically lowest geologic unit that forms Black Mesa and is composed of three members as shown on **Figure 3.3-2**. The Dakota is highly variable in thickness and lithology (Nations et al. 2000). The next stratigraphically higher geologic unit is the Mancos Formation which is composed of 475 to 700 feet of siltstone and claystone that is a slope former and is deeply incised in drainages where it is exposed. The Mancos grades upward into the Toreva Formation at the base of the Mesaverde Group. The Toreva Formation consists of three members: a lower sandstone that is a cliff-former, a middle member composed of rocks of highly variable lithology, and an upper sandstone member. The sandstone members are fairly continuous and widespread across Black Mesa, but the middle member thins from south to north where it appears to have been removed by erosion (Nations et al. 2000).

Above the Toreva Formation is the Wepo Formation, which is the primary coal-bearing unit on Black Mesa. The Wepo Formation is composed of upper and lower members that are separated in part by the Wind Rock Tongue of the Mancos Shale and the Rough Rock Sandstone (Franczyk 1988). The members of the Wepo Formation are similar in composition and consist of coal, carbonaceous siltstone, mudstone, and tabular and lenticular sandstone bodies (Nations et al. 2000). The Wepo Formation forms slopes and benches and is exposed on the top and sides of the mesa. The coals in the Wepo are generally found in the undifferentiated part of the formation where the upper and lower members are not separated by the Wind Rock Tongue of the Mancos Shale and the Rough Rock Sandstone. In the northern part of Black Mesa, the Yale Point Sandstone overlies the Wepo Formation. The Yale Point Sandstone was largely removed by erosion, but forms prominent cliffs along the north wall of Black Mesa.

Although there are coals in the other formations that make up Black Mesa, the Wepo Formation coals are the most economic to mine because, on average, the seams are thicker, have the highest quality, and are the most mineable reserves (Nations et al. 2000). The coals occur in seven identified coal zones designated by color and are in ascending order: Orange, Brown, Yellow, Red, Blue, Green, and Violet (PWCC 2012 et seq.). Mineable coals range from 3 to 8 feet thick, but can be as much as 20 feet thick. The net thickness of Wepo coals is 60 feet on the north side of Black Mesa. Net thickness across the mine area varies from 20 to 60 feet (Nations et al. 2000). Coal quality is measured by heat value, sulfur content, and ash content (residue of mineral matter after combustion). The higher heating value and lower sulfur and ash content of the Wepo Formation coals results in generally higher quality coal than coals from the Dakota and Toreva formations. The average coal quality parameters of Wepo Formation coals at the Kayenta Mine are as follows on an as-received basis: heat value of 10,900 British thermal units per pound; sulfur content of 0.5 percent; and ash content of 7.5 percent. The coal is ranked as bituminous to sub-bituminous (Nations et al. 2000). By contrast, the average as received quality parameters for the Dakota Formation coals, on an as-received basis, are heat value of 8,934 British thermal units per pound, sulfur content of 1.3 percent; ash content of 14.9 percent and a ranking of sub-bituminous. Toreva coals averaged, on an as-received basis, a heat value of 9,756 British thermal units per pound, sulfur content of 0.93 percent, ash content 18.75 percent, and a sub-bituminous rank.

3.3.3.3 Transmission Systems and Communication Sites

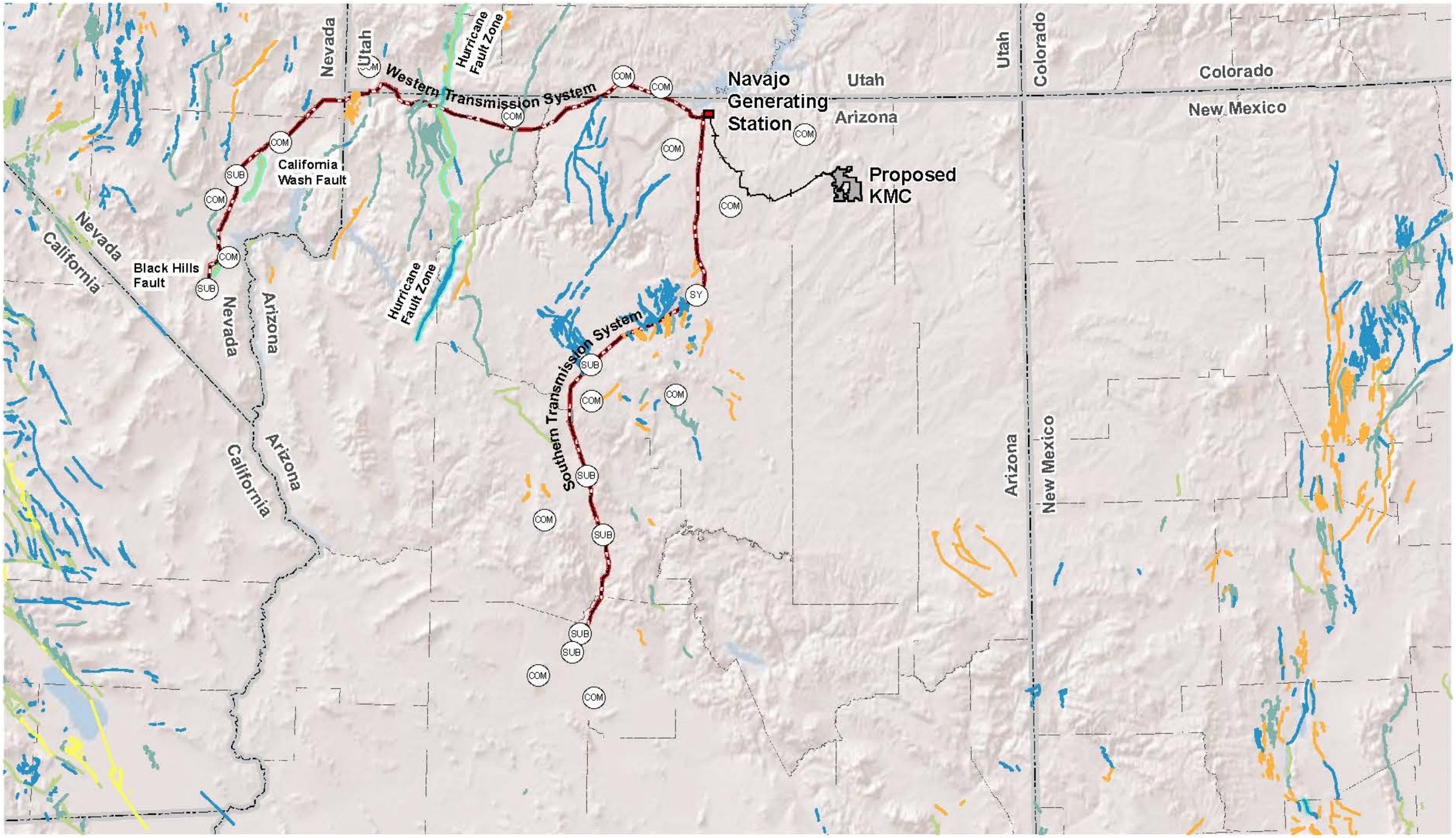
3.3.3.3.1 Western Transmission System

The Western Transmission System (WTS) crosses valley fill deposits, Paleozoic, Triassic and Tertiary sedimentary and volcanic rocks (tuffs and lava flows) (Longwell et al. 1965; Stewart and Carlson 1978). The Paleozoic rocks include the Pennsylvanian-Permian Bird Spring Formation, Permian Coconino Sandstone, and Kaibab Limestone. Triassic rocks include the Chinle, Moenkopi, and Thaynes formations. Tertiary rocks consist of the Muddy Creek and the Miocene Horse Spring formations and undivided volcanic rocks.

The WTS crosses, or is in close proximity to, three major fault zones (**Figure 3.3-4**). The first is the Las Vegas Shear Zone, a major east-west feature that is considered a mid-Cenozoic feature and therefore, is not classified as an active fault (DePolo 2008). Because the Las Vegas Shear zone is not a Quaternary fault, it is not included in the Quaternary Fold and Fault Database (U.S. Geological Survey and Nevada Bureau of Mines and Geology 2006). Another potentially active major fault zone is the California Wash fault that forms the boundary of California Wash and the Muddy Mountains northeast of Las Vegas, Nevada (Anderson 1999a). The fault cuts Holocene material and therefore, is believed to be active. The WTS also crosses the Hurricane fault zone which extends over 100 miles from north to south from the vicinity of Hurricane, Utah, to about 20 miles north of Interstate 40 in Arizona. The Anderson Junction section of the Hurricane fault zone that is crossed by the corridor is considered to be potentially active (Black et al. 2004).

The WTS crosses or is near a small active fault zone located along the southeast base of the Black Hills at the north end of the McCullough Range just southwest of Railroad Pass, southeast of Las Vegas, Nevada. The Black Hills fault zone cuts Holocene deposits that are estimated to be 5,000 years old (Anderson 1999b).

In addition to the potentially active faults that are crossed by the WTS, horizontal ground motions are expected to range from 14 to 30 percent of the acceleration gravity with a 2 percent probability of exceedance in 50 years (Petersen et al. 2015). The strongest ground motions (twenty to thirty percent of the acceleration of gravity) are expected to occur north of Las Vegas where the WTS generally follows the route of Interstate 15 in northeast Clark County, Nevada.



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Quaternary Fault Lines
- < 1,600,000 Years
- < 750,000 Years
- < 130,000 Years
- < 15,000 Years
- < 150 Years
- Fault Zone

- Navajo Generating Station
- Substation
- Switchyard
- Communication Site
- Transmission Line
- BM & LP Railroad
- Coal Lease Boundary
- Proposed KMC

- State Boundary
- County Boundary

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 3.3-4

Quaternary Faults

0 10 20 30 60 90 Miles
0 10 20 30 60 90 Kilometers
1:4,000,000

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In late March to early April 2016, a swarm of 18 small earthquakes occurred in northwest Arizona (Conway 2016). The epicenters line up north to south roughly parallel to the Arizona-Nevada state line and are about 30 miles south of the WTS (**Figure 3.3-4**). The magnitudes ranged from 0.7 to 2.6 and no damage or injuries were reported. The swarm is not associated with any identified active faults.

3.3.3.3.2 Southern Transmission System

The Southern Transmission System (STS) is in the Colorado Plateau and Basin and Range provinces and the transitional area between the provinces. The bedrock in the northern portion of the corridor is composed of the San Rafael and Glen Canyon Groups. South of Moenkopi the route turns southwest and skirts the edge of the San Francisco Volcanic field (Arizona Geological Survey 2015a). The bedrock consists of Miocene to Holocene volcanic rocks. Where volcanic rocks are not present, the corridor is underlain by Paleozoic rocks. Further south in the Prescott Valley, the corridor is underlain by Pliocene- and Miocene-aged valley fill deposits. South of the Prescott Valley in the Agua Fria area, the bedrock consists of Precambrian igneous and meta-igneous and Miocene basalts. In the northern outskirts of Phoenix where the corridor terminates, it is underlain by Pleistocene to Holocene valley fill deposits and basalt. The corridor does not cross any active faults (U.S. Geological Survey and Arizona Geological Survey 2006). Horizontal ground motions are expected to be from less than 8 to 16 percent of the acceleration gravity with a 2 percent probability of exceedance in 50 years (Petersen et al. 2015). Fissures are a potential hazard in the north Phoenix area. Although fissures have not been identified in or along the corridor, the Arizona Geological Survey has several fissure study areas close to the corridor (Arizona Geological Survey 2015b). Landslide hazards may be present along mesa walls and escarpments.

3.3.3.3.3 Communication Sites

Table 3.3-1 lists the communication sites and the geologic formations or deposit which underlie each site. No unique geologic formations were identified at the communication sites, nor were any geologic hazards found to be associated with the sites.

Table 3.3-1 Geologic Units at Communication Sites

Site Name	Formation/Unit	Age	Description
Apex to Crystal	Redwall Limestone and Supai Group	Mississippian to Early Permian	Limestone and sandstone
Beaver Dam	Redwall	Mississippian	Limestone and dolomite
Bill Williams	No formation name	Middle Miocene to Pliocene	Rhyolite and dacite
Buckskin Mountain	Toroweap	Early Permian	Limestone and evaporite
Glen Canyon	Dune sand	Quaternary	Sand
Glendale	Muav Limestone	Middle Cambrian to Late Cambrian	Limestone and dolomite
Jack's Peak	Glen Canyon Group	Early Jurassic	Sandstone
Moenkopi	Chinle Formation Shinarump Member	Late Triassic	Sandstone conglomerate
Mount Elden	No formation name	Middle Pliocene to Holocene	Andesite and dacite
Mount Francis	Precambrian	Early Proterozoic	Granite and Granodiorite
Navajo	Glen Canyon Group	Early Jurassic	Sandstone
NGS	Glen Canyon Group	Early Jurassic	Sandstone
Pipe Springs	Glen Canyon Group	Early Jurassic	Sandstone
Preston Mesa	Glen Canyon Group	Early Jurassic	Sandstone
Red Mountain	No formation name	Early Miocene to Early Pliocene	Basalt and andesite

Table 3.3-1 Geologic Units at Communication Sites

Site Name	Formation/Unit	Age	Description
West Phoenix	Unconsolidated material	Middle to Late Pleistocene	Sand and gravel
Westwing	Unconsolidated material	Middle to Late Pleistocene	Sand and gravel
White Tank	Precambrian	Early Proterozoic	Granite and granodiorite
Zilnez Mesa	Glen Canyon Group	Early Jurassic	Sandstone

Source: Arizona Geological Survey 2015b; Stewart and Carlson 1978.

3.3.4 Environmental Consequences

Data from a variety of sources including governmental agencies, academic institutions, other published information, and information from the applicant were reviewed to provide a description of the geologic environment (Section 3.3.5). The description of the geology was used to analyze potential impacts of the alternatives.

3.3.4.1 Issues

The purpose of the Geology and Landforms section is to analyze whether the Proposed Action or alternatives would cause a physical change in surface or subsurface rock characteristics that potentially would damage or destroy unique geologic features or landforms or impacts that result in the exposure of people or structures to geologic hazards. The issues analyzed in this section are listed below.

Issue 1 – Unique Geologic Features

- Potential for damage or destruction to unique geologic features.

Issue 2 – Geologic Hazards

- Potential risk geologic hazards pose to people or structures.

Issue 3 – Geologic Strata or Landform Changes

- Potential for modification of the geologic strata or topography.

Unique geologic features would consist of, for example, hoodoos, arches, bridges, badlands, or cross bedding that have scientific or aesthetic value. The specific threshold for impacts to unique geologic features and landforms would be whether the action would result in a permanent alteration or destruction of unique geologic features or landforms, the loss of which would be considered adverse to science or human experience.

Geologic hazards are “natural processes” that threaten harm to people and property (Creath 1966). The impact threshold for geologic hazards is the degree of risk that such hazards would pose to people and structures due to seismic hazards, landslides or unstable ground or ground fissures.

3.3.4.2 Assumptions and Impact Methodology

It was assumed that no field surveys would be conducted to collect data and that data would be acquired from readily available published or government agency sources or information provided by the NGS

Participants and PWCC. An assumption with regard to the analysis of geologic hazards is that hazard risk would not change from current conditions over the lifetime of the project.

The methodology for analysis of potential impacts is to review the available data and make a determination whether there are any unique geologic features as defined above and if there is a potential that actions would result in impacts to the resource. With regard to geologic hazards, the methodology for analysis includes review of the various geologic sources, determination of what geologic hazards would be present, and disclosure of the level of risk those hazards would pose to the subject facilities and infrastructure.

3.3.4.3 Proposed Action

3.3.4.3.1 Navajo Generating Station

3.3.4.3.1.1 Unique Geologic Features

No impacts to unique geologic features are anticipated as a result of the Proposed Action because no unique features or formations were identified.

3.3.4.3.1.2 Geologic Hazards

Implementation of the Proposed Action would not result in impacts from geologic hazards because no hazards were identified in the vicinity of the NGS and associated facilities including the BM&LP Railroad.

3.3.4.3.1.3 Geologic Strata or Landform Changes

Implementation of the Proposed Action would not result in impacts to geologic strata at NGS. Minor landform changes would occur as a result of expansion of the coal combustion residuals disposal site under the 3-Unit Operation (**Table 2-4**). There would be no need to expand the existing coal combustion residuals disposal site under the 2-Unit Operation.

3.3.4.3.2 Proposed Kayenta Mine Complex

3.3.4.3.2.1 Unique Geologic Features

No impacts to unique geologic features are anticipated as a result of the Proposed Action because no unique features or formations were identified in the vicinity of the proposed KMC.

3.3.4.3.2.2 Geologic Hazards

Implementation of the Proposed Action (3-Unit Operation or 2-Unit Operation) would not result in impacts from geologic hazards. The cracks and accompanying subsidence that have been observed on the Black Mesa are a scoping issue of concern. However, they are not expected to pose a concern to coal mine operations because the cracks are found in alluvial areas and are not associated with mining (OSMRE 2011). Subsidence due to pumping from an aquifer results when the aquifer is compressed as groundwater is withdrawn. As the aquifer is compressed, the ground subsides. Aquifer compression can be estimated by relating the amount of drawdown to the storage coefficient of the aquifer. The storage coefficient is a measure of the amount of water released from storage per unit of surface area of the aquifer per unit change in head (Case et al. 2003; Edgar and Case 2000). The amount of compression of the aquifer is the product of the storage coefficient (dimensionless) and the amount of drawdown (feet). For the N-Aquifer with confined storage coefficients that range from 2.2×10^{-5} to 8.0×10^{-3} (OSMRE 2011) and an expected drawdown of 100 feet (Section 3.7), the amount of compression would range from 0.02 foot to 0.8 foot. For the D-Aquifer with a confined storage coefficient of 3×10^{-7} (Section 3.7) and an expected drawdown of 150 feet, the compression of the aquifer is expected to be 5×10^{-5} foot. Given the small amounts of expected compression in these aquifers, subsidence would not be observed on the surface. The cracks and subsidence that have been observed on Black Mesa are most likely eroded desiccation cracks as described above rather than fissures created by groundwater withdrawal.

The cracks have not resulted from mining activities or groundwater withdrawals related to mining nor are the cracks due to landslides or seismic activity. No impacts to mine facilities due to landslides and seismic events are anticipated.

3.3.4.3.2.3 Geologic Strata or Landform Changes

Because mining would occur under the Proposed Action, removal of overburden material would continue in order to mine the coal. **Table 3.3-2** summarizes the amounts of material (overburden and topsoil) that would be removed under the 3-Unit Operation and 2-Unit Operation. The 2-Unit Operation would have less impact since less coal would be mined resulting in less impact to overburden materials. After the coal is removed, the overburden is backfilled into the pit. The process of extracting the coal would result in direct impacts through permanent disruption of the original strata and a change in topography. The disturbance would be a minor impact since the geologic strata would not be considered unique and the topography would be restored according to regulation. One of the objectives of reclamation is to restore, to the extent possible, the original contours of the land surface prior to mining, including irregularities in the restored surface. In addition to restoring pre-mining topography, the backfill must be stabilized to prevent erosion and provide for a return to pre-mining uses, which in the case of the Kayenta Mine is rangeland grazing, wildlife habitat, and cultural plants (PWCC 2012 et seq.). Erosion of the backfilled areas is a minor, but potential long-term indirect effect. However, erosion control structures and appropriate grading combined with establishment of a diverse and permanent vegetation cover would be used to lessen the effects of erosion (OSMRE 2011; PWCC 2012 et seq.).

Table 3.3-2 Overburden Disturbance: High and Low Production Comparison

	3-Unit Operation (million tpy)	2-Unit Operation (million tpy)
Annual Coal Production	8.1	5.5
Overburden and Topsoil[1]	97	65

[1] Assumes a stripping ratio of 5.1 bank cubic yards of overburden per ton of coal mined (Section 2.3.1.2); 2.35 tons per bank cubic yard (Caterpillar 2015).

tpy = tons per year.

3.3.4.3.3 Transmission Systems and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

3.3.4.3.3.1 Unique Geologic Features

No impacts to unique geologic features are anticipated as a result of the Proposed Action because no unique features or formations were identified in the vicinity of the transmission systems and communication sites.

3.3.4.3.3.2 Geologic Hazards

<u>Western Transmission System</u>

The WTS is located in areas (southwestern Utah and southern Nevada) where active faults are located that could generate earthquakes and result in horizontal ground motions of up to 30 percent of the acceleration of gravity. Accelerations of 25 to 30 percent of the acceleration of gravity could result in slight damage to specially designed structures, but there may be considerable damage to ordinary substantial buildings, including partial collapse. Also, there would be much damage to poorly built structures which could cause chimneys, smokestacks, columns, monuments, and walls to fall (Bolt 1993; U.S. Geological Survey 2014).

Electrical transmission system vulnerability to seismic effects depends on which system components are involved. Transmission towers generally survive well in earthquake events since they are lightweight structures at independent locations connected by conductors that have the ability to adjust to the vibrations of ground motion (Rocky Mountain Power 2010). In addition, the towers are built to a standard for wind and ice structural loading and as such, exceed earthquake design loads (American Society of Civil Engineers 1991). However, transmission structures are at a somewhat greater risk when built on soils prone to liquefaction. Liquefaction potential exists where water tables are high and the soils are loose and sandy, but no liquefaction-prone areas were identified. Other facilities such as substations and associated equipment such as ceramic insulators do not fare well unless specific design considerations are built in or are retrofitted to existing facilities (Yokel 1990).

The transmission systems were constructed before the U.S. Geological Survey and state geological surveys began comprehensive research programs to determine which young faults (less than 1.6 million years old) had the potential to be active sources for strong earthquakes. As described in Section 3.3.1.4, the WTS crosses over or is close to faults that have been determined to be active. As described in the previous paragraph, transmission systems are likely to withstand seismic motions. The seismic hazards represent a direct, minor impact to the WTS. The seismic hazards are not contingent on either option of 3-Unit Operation or 2-Unit Operation.

The WTS would not impact any unique geologic resources and no other geologic hazards were identified that would affect the corridor.

<u>Southern Transmission System</u>

The STS does not cross any faults that have been determined to be active. Seismic hazard mapping indicates that there is low potential for strong ground motions to affect the transmission line corridor and associated substations. Although ground fissures have been mapped a few miles from the corridor terminus north of Phoenix, the possibility exists that such hazards have yet to be manifested since the mechanisms of fissure formation are part of a dynamic process (groundwater withdrawal from unconsolidated valley fill). The potential hazards from fissure formation would be negligible and are not dependent upon 3-Unit Operation or 2-Unit Operation.

<u>Communication Sites</u>

No geologic hazards were identified in the vicinity of the communication sites.

3.3.4.3.3.3 Geologic Strata or Landform Changes

Implementation of the Proposed Action would not result in impacts to geologic strata or landforms as there is no new construction planned for the transmission system or communication sites.

3.3.4.3.4 Project Impact Summary – All Project Components

There would be no impacts to unique geologic features because no such features were identified in the course of the analysis.

There would be no direct impacts to project components from geologic hazards for the NGS and associated facilities, the proposed KMC, and the communication sites. Based on the low seismicity and the absence of identified active source faults, the NGS and associated facilities, the proposed KMC, and the communication sites are not likely to experience damaging earthquake-generated ground motions. The WTS has a minor risk of being affected by seismicity because of its proximity to active faults and areas of higher potential ground motion. The STS has a negligible risk of fissure formation near the terminus north of Phoenix. No other geologic hazards were identified for the project components.

There would be no impacts to geologic strata and topography for most of the NGS site and associated facilities, transmission system, and communication sites. Minor landform changes would occur at the coal combustion residual disposal area at NGS as a result of expansion of the coal combustion residuals disposal site under the 3-Unit Operation only. Direct impacts to landforms at the proposed KMC would be minor since reclamation requirements call for restoring the topography as close to pre-mining conditions as possible.

3.3.4.3.5 Cumulative Impacts

The proposed Manymules water development project is a foreseeable action in the Kayenta mine area. The project includes 46 miles of water pipeline, two water treatment units, pump stations, and water storage in Kayenta mine using well water obtained from PWCC (OSMRE 2011). The Manymules project would have negligible impacts to topography and not contribute to cumulative impacts.

3.3.4.4 Natural Gas Partial Federal Replacement Alternative

Under the Natural Gas Partial Federal Replacement (PFR) Alternative, a selected quantity of power between 100 megawatts (MW) and 250 MW would be contracted for under a long-term power purchase agreement from currently unidentified, existing natural gas generation sources, displacing an equivalent amount of power from the federal share of NGS generation. Because the facility is assumed to currently exist, prior disturbance impacts to unique geologic resources and landforms are not evaluated. The following are key assumptions related to such an existing site:

- Prior impacts to unique geologic features and landform changes are not assessed in this discussion.
- Geologic hazard risks are not assessed in this discussion.
- Whatever the level of geologic hazard risks, those risks would not appreciably change from 2020 to 2044.

Impact issues for the Natural Gas PFR Alternative are discussed across the range of NGS unit operations (3-Unit and 2-Unit) and associated alternative power reductions (100 MW and 250 MW) from the least NGS power reduction to the greatest. Reductions in NGS power generation would proportionally reduce the quantity of coal delivered from the Kayenta Mine.

This discussion distinguishes differences in impacts within the natural gas replacement alternative operational range to provide a basis for comparison with the Proposed Action.

3.3.4.4.1 Navajo Generating Station

3.3.4.4.1.1 Unique Geologic Features

As with the Proposed Action, under the Natural Gas PFR Alternative there would be no impacts to unique geologic features because no such features have been identified at the NGS site.

3.3.4.4.1.2 Geologic Hazards

As with the Proposed Action, under the Natural Gas PFR Alternative there would be no impacts due to geologic hazards because no hazards were identified in the vicinity of the NGS and associated facilities including the BM&LP Railroad.

3.3.4.4.1.3 Geologic Strata or Landform Changes

As with the Proposed Action, under the Natural Gas PFR Alternative there would be no impacts to geologic strata at NGS. Minor landform changes would occur as a result of expansion of the coal combustion residuals disposal site under the 3-Unit Operation for both the 100-MW and 250-MW replacement options. These landform changes would be less than under the Proposed Action due the overall reduction in coal combustion residuals. There would be no need to expand the existing coal combustion residuals disposal site under the 2-Unit Operation for the 100-MW and 250-MW options.

3.3.4.4.2 Proposed Kayenta Mine Complex

If 100 MW to 250 MW of power generation were replaced at NGS by natural gas alternative sources, the proposed KMC would mine less coal. For the 3-Unit Operation, 7.7 million tpy would be mined at the 100-MW natural gas replacement option and 7.1 million tpy under the 250-MW replacement option. For the 2-Unit Operation 5.1 million tpy would be mined under the 100-MW natural gas replacement option and 4.5 million tpy would be mined under the 250-MW option.

3.3.4.4.2.1 Unique Geologic Features

As with the Proposed Action, there would be no impacts to unique geologic features because no such features have been identified at the proposed KMC.

3.3.4.4.2.2 Geologic Hazards

There would be no impacts due to geologic hazards because no hazards were identified in the vicinity of the proposed KMC.

3.3.4.4.2.3 Geologic Strata or Landform Changes

Impacts to overburden and landform changes would be minor but slightly less than the Proposed Action since less coal would be mined which would result in less overall disturbance. **Table 3.3-3** shows the amount of overburden that would be disturbed under the Natural Gas PFR Alternative and other PFR alternatives as compared to the Proposed Action, 3-Unit Operation and 2-Unit Operation. The Natural Gas PFR Alternative would disturb less overburden as compared to the Proposed Action. As would be expected, there are large reductions in disturbance when comparing the 3-Unit Operation and 2-Unit Operation because the one-third reduction in coal that is mined would result in a commensurate reduction in overburden that is disturbed. There are smaller differences between the 100-MW and 250-MW scenarios. From 2040 to 2044, the stripping ratio is expected to increase from 5.1 to 7.1 bank cubic yards of overburden per ton of coal mined (Section 2.3.1.2). The stripping ratio for the last few years of operation would increase the overall overburden disturbance, but the relative differences between action alternatives would not be expected to change.

Table 3.3-3 Proposed KMC Annual Coal Production and Annual Overburden Disturbance

		Proposed Action	Natural Gas PFR		Renewable PFR		Tribal PFR	
			100 MW	250 MW	100 MW	250 MW	100 MW	250 MW
NGS 3-Unit Operation	Annual Coal Production (million tpy)	8.1	7.7	7.1	7.9	7.5	7.9	7.7
	Overburden[1] (million tpy)	97	92.5	85.5	94.4	90.3	95.2	92.3

Table 3.3-3 Proposed KMC Annual Coal Production and Annual Overburden Disturbance

		Proposed Action	Natural Gas PFR		Renewable PFR		Tribal PFR	
			100 MW	250 MW	100 MW	250 MW	100 MW	250 MW
NGS 2-Unit Operation	Annual Coal Production (million tpy)	5.5	5.1	4.5	5.3	4.9	5.3	5.1
	Overburden[1] (million tpy)	65.0	61.3	54.4	63.2	59.1	64.0	61.1

[1] Assumes a stripping ratio of 5.1 bank cubic yards of overburden per ton of coal mined (Section 2.3.1.2, **Table 3.3-2**); 2.35 tons per bank cubic yard.

tpy = tons per year.

3.3.4.4.3 Transmission Systems and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

3.3.4.4.3.1 Unique Geologic Features

As with the Proposed Action, there would be no impacts to unique geologic features under the Natural Gas PFR Alternative because no such features have been identified within the transmission systems corridors or communication sites.

3.3.4.4.3.2 Geologic Hazards

As with the Proposed Action, there would be no direct impacts to project components from geologic hazards for the STS and the communication sites. Based on the low seismicity and the absence of identified active source faults, the STS and the communication sites are not likely to experience damaging earthquake-generated ground motions. The WTS has a minor risk of being affected by seismicity because of its proximity to active faults and areas of higher potential ground motion. The STS has a negligible risk of fissure formation near the terminus north of Phoenix.

3.3.4.4.3.3 Geologic Strata or Landform Changes

There would be no impacts to geologic strata or landform changes for the exiting transmission systems and communication sites because no changes would occur due to the implementation of the Natural Gas PFR Alternative.

3.3.4.4.4 Project Impact Summary – All Project Components

As with the Proposed Action, there would be no impacts to unique geologic features since no such features were identified in the course of the analysis.

As with the Proposed Action, there would be no direct impacts to project components from geologic hazards for the NGS and associated facilities, the proposed KMC, and the communication sites. Based on the low seismicity and the absence of identified active source faults, the NGS and associated facilities, the proposed KMC, and the communication sites are not likely to experience damaging earthquake-generated ground motions. The WTS has a minor risk of being affected by seismicity because of its proximity to active faults and areas of higher potential ground motion. The STS has a negligible risk of fissure formation near the terminus north of Phoenix. No other geologic hazards were identified for the project components.

Overall there would be no impacts to geologic strata and landforms for most of the NGS site and associated facilities, transmission system, and communication sites. Minor landform changes would occur at the coal combustion residual disposal area at NGS as a result of expansion of the coal combustion residuals disposal site under the 3-Unit Operation, 100 MW and 250 MW options. These landform changes would be less than under the Proposed Action due the overall reduction in coal combustion residuals. Direct impacts to geologic strata and landform changes of the overburden at the proposed KMC would be minor, but less than the Proposed Action, since reclamation requirements call for restoring the landform changes as close to pre-mining conditions as possible.

3.3.4.4.5 Cumulative Impacts

No reasonably foreseeable future actions are expected to occur that would intersect with the cumulative effects study area for geology and landforms as defined in Section 3.3.2. Because there would be no impacts from reasonably foreseeable future actions, no cumulative impacts are expected to occur.

3.3.4.5 Renewable Partial Federal Replacement Alternative

Under the Renewable PFR Alternative, a selected quantity of power between 100 MW and 250 MW would be contracted for under a long-term power purchase agreement from a currently unidentified, existing renewable energy power source, displacing an equivalent amount of power from the federal share of NGS generation. As with the Natural Gas PFR Alternative, because the facility is assumed to currently exist, prior disturbance impacts to unique geologic resources and landforms are not evaluated. The following are key assumptions related to such an existing site:

- Prior impacts to unique geologic features and landform changes and are not assessed in this discussion.
- Geologic hazard risks are not assessed in this discussion.
- Regardless of the level of geologic hazard risks, those risks would not appreciably change from 2020 to 2044.

Impact issues for the Renewable PFR Alternative are discussed across the range of NGS unit operations (3-Unit and 2-Unit) and associated alternative power reductions (100 MW and 250 MW) from the least NGS power reduction to the greatest. Reductions in NGS power generation would proportionally reduce the quantity of coal delivered from the Kayenta Mine.

This discussion distinguishes differences in impacts within the Renewable PFR Alternative operational range to provide a basis for comparison with the Proposed Action.

The following discusses the impacts to geology and landforms if 100 MW to 250 MW of power generation were replaced at NGS by alternative power purchased from an unknown, but existing source of power from renewable energy. As the site is assumed to be an existing facility, prior disturbance impacts to geology and landforms are not evaluated.

3.3.4.5.1 Navajo Generating Station

3.3.4.5.1.1 Unique Geologic Features

As with the Proposed Action, there would be no impacts to unique geologic features under the Renewable PFR Alternative because no such features have been identified at the NGS site.

3.3.4.5.1.2 Geologic Hazards

As with the Proposed Action, there would be no impacts due to geologic hazards under the Renewable PFR Alternative because no hazards were identified in the vicinity of the NGS and associated facilities including the BM&LP Railroad.

3.3.4.5.1.3 Geologic Strata or Landform Changes

As with the Proposed Action, under the Renewable PFR Alternative there would be no impacts to geologic strata at NGS. Minor landform changes would occur as a result of expansion of the coal combustion residuals disposal site under the 3-Unit Operation for both the 100-MW and 250-MW replacement options. These landform changes would be less than under the Proposed Action due the overall reduction in coal combustion residuals. There would be no need to expand the existing coal combustion residuals disposal site under the 2-Unit Operation for the 100-MW and 250-MW options.

3.3.4.5.2 Proposed Kayenta Mine Complex

If 100 MW to 250 MW of power generation were replaced at NGS by renewable sources, the proposed KMC would mine less coal. For the 3-Unit Operation, 7.9 million tpy would be mined under the 100-MW replacement option and 7.5 million tpy under the 250-MW replacement option. For the 2-Unit Operation 5.3 million tpy would be mined under the 100-MW option and 4.9 million tpy would be mined under the 250-MW option.

3.3.4.5.2.1 Unique Geologic Features

As with the Proposed Action, there would be no impacts to unique geologic features under the Renewable PFR Alternative because no such features have been identified at the proposed KMC.

3.3.4.5.2.2 Geologic Hazards

As with the Proposed Action, there would be no impacts due to geologic hazards under the Renewable PFR Alternative because no hazards were identified in the vicinity of the proposed KMC.

3.3.4.5.2.3 Geologic Strata or Landform Changes

Impacts to overburden and landform changes would be minor but slightly less than the Proposed Action since less coal would be mined which would result in less overall disturbance. **Table 3.3-3** shows the amount of overburden that would be disturbed under the Renewable PFR Alternative and other PFR alternatives as compared to the Proposed Action, 3-Unit Operation and 2-Unit Operation. The Renewable PFR Alternative would disturb less overburden as compared to the Proposed Action. However, the Renewable PFR Alternative would disturb more overburden in comparison to the Natural Gas PFR Alternative, since more coal would be mined.

3.3.4.5.3 Transmission Systems and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

3.3.4.5.3.1 Unique Geologic Features

As with the Proposed Action, there would be no impacts to unique geologic features under the Renewable PFR Alternative because no such features have been identified within the transmission systems corridors or communication sites.

3.3.4.5.3.2 Geologic Hazards

As with the Proposed Action, there would be no direct impacts to the STS and communication sites from geologic hazards. Based on the low seismicity and the absence of identified active source faults, the STS and the communication sites are not likely to experience damaging earthquake-generated ground motions. The WTS has a minor risk of being affected by seismicity because of its proximity to active faults and areas of higher potential ground motion. The STS has a negligible risk of fissure formation near the terminus north of Phoenix.

3.3.4.5.3.3 Geologic Strata or Landform Changes

There would be no impacts to geologic strata or landform changes for the exiting transmission systems and communication sites because no changes would occur due to the implementation of the Renewable PFR Alternative.

3.3.4.5.4 Project Impact Summary – All Project Components

As with the Proposed Action, there would be no impacts to unique geologic features since no such features were identified in the course of the analysis.

As with the Proposed Action, there would be no direct impacts to project components from geologic hazards for the NGS and associated facilities, the proposed KMC, and the communication sites. Based on the low seismicity and the absence of identified active source faults, the NGS and associated facilities, the proposed KMC, and the communication sites are not likely to experience damaging earthquake-generated ground motions. The WTS has a minor risk of being affected by seismicity because of its proximity to active faults and areas of higher potential ground motion. The STS has a negligible risk of fissure formation near the terminus north of Phoenix.

Overall there would be no impacts to geologic strata and landforms for most of the NGS site and associated facilities, transmission system, and communication sites. Minor landform changes would occur at the coal combustion residual disposal area at NGS as a result of expansion of the coal combustion residuals disposal site under the 3-Unit Operation, 100 MW and 250 MW options. These landform changes would be less than under the Proposed Action due the overall reduction in coal combustion residuals. Direct impacts to geologic strata and landform changes of the overburden at the KMC would be minor, but less than the Proposed Action, since reclamation requirements call for restoring the landform changes as close to pre-mining conditions as possible.

3.3.4.5.5 Cumulative Impacts

No reasonably foreseeable actions are expected to occur that would intersect with the cumulative effects study area for geology and landforms as defined in Section 3.3.2. Because there would be no impacts from reasonably foreseeable future actions, no cumulative impacts are expected to occur.

3.3.4.6 Tribal Partial Federal Replacement Alternative

Under the Tribal PFR Alternative, between 100 MW and 250 MW of power generation from the NGS would be replaced by power supplied by a new photovoltaic generation facility on tribal land, displacing an equivalent amount of power from the federal share of NGS generation. The construction of a new photovoltaic generation site on tribal land would result in between 1,200 and 3,000 acres of new surface disturbance. The Tribal PFR facility would be analyzed in a separate NEPA process once a facility location is identified. The following discussion relates to impacts to the existing facilities.

3.3.4.6.1 Navajo Generating Station

3.3.4.6.1.1 Unique Geologic Features

Under the Tribal PFR Alternative there would be no impacts to unique geologic features because no such features have been identified at the NGS site.

3.3.4.6.1.2 Geologic Hazards

As with the Proposed Action, there would be no impacts due to geologic hazards because no hazards were identified in the vicinity of the NGS and associated facilities including the BM&LP Railroad.

3.3.4.6.1.3 Geologic Strata or Landform Changes

As with the Proposed Action, under the Tribal PFR Alternative there would be no impacts to geologic strata at NGS. Minor landform changes would occur as a result of expansion of the coal combustion residuals disposal site under the 3-Unit Operation for both the 100-MW and 250-MW replacement options. These landform changes would be less than under the Proposed Action due the overall reduction in coal combustion residuals. There would be no need to expand the existing coal combustion residuals disposal site under the 2-Unit Operation for the 100-MW and 250-MW options.

3.3.4.6.2 Proposed Kayenta Mine Complex

If 100 MW to 250 MW of power generation were replaced at NGS by alternative sources purchased by Bureau of Reclamation (Reclamation) from a new photovoltaic generation site on tribal land, there would be less coal mined at the proposed KMC.

3.3.4.6.2.1 Unique Geologic Features

As with the Proposed Action, there would be no impacts to unique geologic features because no such features have been identified at the proposed KMC.

3.3.4.6.2.2 Geologic Hazards

As with the Proposed Action, there would be no impacts due to geologic hazards because no hazards were identified in the vicinity of the proposed KMC.

3.3.4.6.2.3 Geologic Strata or Landform Changes

Impacts to overburden and landform changes would be minor but slightly less than the Proposed Action since less coal would be mined which would result in less overall disturbance. **Table 3.3-3** shows the amount of overburden that would be disturbed under the Tribal PFR alternatives as compared to the Proposed Action, 3-Unit Operation and 2-Unit Operation. However, the Tribal PFR Alternative would disturb more overburden in comparison to the other PFR alternatives, because more coal would be mined.

3.3.4.6.3 Transmission Systems and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

3.3.4.6.3.1 Unique Geologic Features

As with the Proposed Action, there would be no impacts to unique geologic features under the Tribal PFR Alternative because no such features have been identified within the transmission systems corridors or communication sites.

3.3.4.6.3.2 Geologic Hazards

As with the Proposed Action, there would be no direct impacts to the STS and communication sites. Based on the low seismicity and the absence of identified active source faults, the STS and the communication sites are not likely to experience damaging earthquake-generated ground motions. The WTS has a minor risk of being affected by seismicity because of its proximity to active faults and areas of higher potential ground motion. The STS has a negligible risk of fissure formation near the terminus north of Phoenix.

3.3.4.6.3.3 Geologic Strata or Landform Changes

There would be no impacts to geologic strata or landform changes for the exiting transmission systems and communication sites. Any changes resulting from tie-in to the existing transmission system for the new photovoltaic power source would be addressed in a separate NEPA action.

3.3.4.6.4 Project Impact Summary – All Project Components

As with the Proposed Action, there would be no impacts to unique geologic features since no such features were identified in the course of the analysis.

As with the Proposed Action, there would be no direct impacts to project components from geologic hazards for the NGS and associated facilities, the proposed KMC, and the communication sites. Based on the low seismicity and the absence of identified active source faults, the NGS and associated facilities, the proposed KMC, and the communication sites are not likely to experience damaging earthquake-generated ground motions. The WTS has a minor risk of being affected by seismicity because of its proximity to active faults and areas of higher potential ground motion. The STS has a negligible risk of fissure formation near the terminus north of Phoenix.

Overall there would be no impacts to geologic strata and landforms for most of the NGS site and associated facilities, transmission system, and communication sites. Minor landform changes would occur at the coal combustion residual disposal area at NGS as a result of expansion of the coal combustion residuals disposal site under the 3-Unit Operation, 100 MW and 250 MW options. These landform changes would be less than under the Proposed Action due the overall reduction in coal combustion residuals. Direct impacts to geologic strata and landform changes of the overburden at the KMC would be minor, but less than the Proposed Action, because reclamation requirements call for restoring the landform changes as close to pre-mining conditions as possible. The landform changes under the Tribal PFR Alternative would be greater than under other PFR alternatives.

3.3.4.6.5 Cumulative Impacts

No reasonably foreseeable actions are expected to occur that would intersect with the cumulative effects study area for geology and landforms as defined in Section 3.3.2. Because there would be no impacts from reasonably foreseeable future actions, no cumulative impacts are expected to occur.

3.3.4.7 No Action

3.3.4.7.1 Navajo Generating Station

3.3.4.7.1.1 Unique Geologic Features

Under the No Action Alternative, no impacts to unique geologic resources are expected to occur because no unique geologic features have been identified for the NGS.

3.3.4.7.1.2 Geologic Hazards

Geologic hazards would not be a concern because the plant and associated facilities, including the BM&LP Railroad, would be decommissioned and the sites reclaimed. Based on the low seismicity of the area and the absence of identified active source faults the site and railroad are not likely to experience damaging earthquake-generated ground motions. No other geologic hazards were identified at the site.

3.3.4.7.1.3 Geologic Strata or Landform Changes

Under the No Action Alternative the NGS site and BM&LP Railroad would be reclaimed. There would be no impacts to geologic strata and negligible landform changes as a result of the reclamation activities.

3.3.4.7.2 Proposed Kayenta Mine Complex

3.3.4.7.2.1 Unique Geologic Features

Under the No Action Alternative, no impacts to unique geologic resources are expected to occur because no unique geologic features have been identified for the proposed KMC.

3.3.4.7.2.2 Geologic Hazards

There would be no impacts due to geologic hazards because no hazards were identified in the vicinity of the proposed KMC site.

3.3.4.7.2.3 Geologic Strata or Landform Changes

Under the No Action Alternative, no impacts to geologic strata or landform changes are expected. Mining would cease and the disruption of overburden strata would cease. The disturbed areas would be reclaimed to the approximate pre-mining landforms.

3.3.4.7.3 Transmission Systems and Communication Sites

In the event it is determined that some or all of the transmission systems and communication site ROWs are not renewed, a lengthy study and permitting process would need to occur before any decommissioning is initiated due to the essential and integral nature of these facilities with the western electric grid. As noted in Section 2.3.3, up to 4,826 acres within and alongside the transmission system corridors could be temporarily disturbed if the entirety of the transmission systems and communication sites were decommissioned and removed resulting in minor, localized emissions impacts.

3.3.4.7.3.1 Unique Geologic Features

Under the No Action Alternative, no impacts to unique geologic resources are expected to occur because no unique geologic features have been identified for the transmission systems and communications sites.

3.3.4.7.3.2 Geologic Hazards

Since the transmission line systems would continue to operate under the No Action Alternative, the potential impacts and risks due to geologic hazards would continue. There would be no direct impacts to the STS and communication sites. Based on the low seismicity and the absence of identified active source faults, the STS and the communication sites are not likely to experience damaging earthquake-generated ground motions. The WTS has a minor risk of being affected by seismicity because of its proximity to active faults and areas of higher potential ground motion. The STS has a negligible risk of fissure formation near the terminus north of Phoenix.

3.3.4.7.3.3 Geologic Strata or Landform Changes

There would be no impacts to geologic strata or landform changes for the exiting transmission systems and communication sites because no changes are planned.

3.3.4.7.4 No Action Impact Summary – All Project Components

For the No Action Alternative, there would be no impacts to unique geologic features because no such features were identified in the course of the analysis.

For the No Action Alternative, there would be no direct impacts to project components from geologic hazards for the NGS and associated facilities, the proposed KMC, and the communication sites. Based on the low seismicity and the absence of identified active source faults, the NGS and associated facilities, the proposed KMC, and the communication sites are not likely to experience damaging earthquake-generated ground motions. The WTS has a minor risk of being affected by seismicity because of its proximity to active faults and areas of higher potential ground motion. The STS has a negligible risk of fissure formation near the terminus north of Phoenix.

Overall, there would be negligible to no impacts to geologic strata and landforms for NGS and the proposed KMC because operations would cease, facilities would be removed, and the sites would be reclaimed. The existing transmission systems and communication sites would remain, but because no changes are proposed, there would be no impacts to geologic strata or landforms at these locations.

3.3.5 References

Allis, R. G., T. C. Chidsey, C. Morgan, J. Moore, S. P. White. 2003. CO_2 Sequestration Potential beneath Large Power Plants in the Colorado Plateau-Southern Rocky Mountain Region, USA. Proceedings, 2nd Annual Conference on Carbon Sequestration, Alexandria, Virginia, May 5-8, 2003. Internet website: http://geology.utah.gov/resources/energy/carbon-sequestration/#tab-id-3. Accessed July 12, 2015.

Allison, M. L. and T. C. Shipman. 2007. Earth Fissure Mapping Program 2006 Progress Report. Arizona Geological Survey Open-file Report 07-01. June, 2007, 26 p.

American Society of Civil Engineers (ASCE). 1991. Guidelines for Electrical Transmission Line Structural Loading. ASCE Manuals and Reports on Engineering Practice No. 74, 139 pp.

Anderson, R. E. (compiler). 1999a. Fault Number 1118, California Wash Fault, in Quaternary Fault and Fold Database of the United States. Internet website: http://earthquakes.usgs.gov/hazards/qfaults. Accessed July 27, 2015.

Anderson, R. E. (compiler). 1999b. Fault Number 1116, Black Hills Fault, in Quaternary Fault and Fold Database of the United States. U.S. Geological. Internet website: http://earthquakes.usgs.gov/hazards/qfaults. Accessed July 27, 2015.

Arizona Geological Survey. 2015a. The Geologic Map of Arizona. Internet website: http://data.azgs.az.gov/geologic-map-of-arizona/#. Accessed July 27, 2015.

Arizona Geological Survey. 2015b. Arizona's Earth Fissure Center. Internet website: http://www.azgs.az.gov/EFC.shtml. Accessed July 27, 2015.

Billingsley, G. H. and S. S. Priest. 2013. Geologic Map of the Glen Canyon Dam 30' x 60' quadrangle, Coconino County, Northern Arizona: U.S. Geological Survey Scientific Investigations Map 3268, pamphlet 43 p., 3 sheets, scale 1:50,000.

Black, B. D., P. A. Pearthree, C. B. DuRoss, M. D. Hylland, S. Hecker, and G. N. McDonald, (compilers). 2004. Fault Number 998c, Hurricane Fault Zone, Anderson Junction section, in Quaternary Fault and Fold Database of the United States. U.S. Geological Survey. Internet website: http://earthquakes.usgs.gov/hazards/qfaults. Accessed July 28, 2015.

Bolt, B. A. 1993. Earthquakes and Geological Discovery, Appendix: Abridged Modified Mercalli Intensity Scale, American Scientific Library.

Case, J. C, T. V. Edgar and R. H. De Bruin. 2003. Subsidence Potential Related to Water Withdrawal in the Powder River Basin. Wyoming State Geological Survey, Wyoming Geo-notes No. 68 December, 2000, p.19-20.

Caterpillar. 2015. Caterpillar Performance Handbook, Edition 45, January 2015. A Publication by Caterpillar, Peoria, Illinois, USA.

Conway, B. A. 2016. Earthquake Swarm in Northwestern Arizona, 29 March – 4 April 2016. http://www.azgs.az.gov/news_releases2016.shtml#apr5. Accessed April 11, 2016.

Conway, M. 2014. Landslides – Mitigating a Clear and Present Danger. Arizona Geology Magazine. Internet website: http://azgeology.azgs.az.gov/article/feature-article/2014/05/landslides-mitigating-clear-and-present-danger. Accessed July 22, 2015.

Cooley, M. E., J. W. Harshbarger, J. P. Akers, and W. F. Hardt. 1969. Regional Hydrogeology of the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah: Geological Survey Professional Paper 521-A, 72 p.

Creath, W. B. 1966. Home Buyers Guide to Geologic Hazards. American Institute of Professional Geologists, Denver, Colorado, 32 p.

DePolo, C. M. 2008. Characterizing the Earthquake Potential of the Las Vegas Valley Fault System [abstract]. Geological Society of America Cordilleran Section (104th Annual) and Rocky Mountain Section (60th Annual) Joint Meeting, Las Vegas, Nevada, March 19-21, 2008.

Edgar, T. V. and J. C. Case. 2000. Pumping Induced Settlement of Aquifers. Wyoming State Geological Survey, Preliminary Hazards Report PHR 00-1. 10 pp.

Fenneman, N. M. 1928. Physiographic Divisions of the United States: Annals of the Association of American Geographers 18(4):261-353. December 1928.

Franczyk, K. J. 1988. Stratigraphic Revision and Depositional Environments of the Upper Cretaceous Toreva Formation in the Northern Black Mesa Area, Navajo and Apache Counties, Arizona: U.S. Geological Survey Bulletin 1685, 38 p.

Haynes, D. D. and R. J. Hackman. 1978. Geology, Structure, and Uranium Deposits of the Marble Canyon 1 Degree x 2 Degree Quadrangle, Arizona: U.S. Geological Survey Miscellaneous Investigations Series Map I-1003, scale 1:250,000.

Kelley, V. C. 1958. Tectonics of the Black Mesa Basin Region of Arizona. In: Black Mesa Basin (Northeastern Arizona). R. Y. Anderson and J. W. Harshbarger (editors). New Mexico Geological Society 9th Annual Fall Field Conference Guidebook, 205 p.

Longwell, C. R., E. H. Pampeyan, B. Bowyer, and R. J. Roberts. 1965. Geology and Mineral Deposits of Clark County, Nevada. Nevada Bureau of Mines and Geology Bulletin 62, 218 p.

Nations, J. D., R. L. Swift, and H. W. Haven, Jr. 2000. Chapter H – Summary of Cretaceous Stratigraphy and Coal Distribution, Black Mesa Basin, Arizona. U.S. Geological Survey Professional Paper 1625–B. In: Geologic Assessment of Coal in the Colorado Plateau, Arizona, Colorado, New Mexico, and Utah. M. A. Kirschbaum, L. N. R. Roberts, and L. R. H. Biewick (editors), 33 p.

Office of Surface Mining Reclamation and Enforcement (OSMRE). 2011. Environmental Assessment: Kayenta Mine Permit (AZ-0001D) Renewal (Navajo County, Arizona). U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement (Western Region). August 2011. 185 pp + appendices.

Office of Surface Mining, Reclamation and Enforcement (OSMRE). 2006. Black Mesa Project Draft Environmental Impact Statement, DOI DES 06-48, OSM-EIS-33, November 2006.

Peabody Western Coal Company (PWCC). 2012, et seq. Kayenta Complex Permanent Program Permit AZ-0001E Life-of-Mine Plan Revision. Submitted to OSMRE May 1, 2012. Last updated March 27, 2015.

Petersen, M. D., M. P. Moschetti, P. M. Powers, C. S. Mueller, K. M. Haller, A. D. Frankel, Y. Zeng, S. Rezaeian, S. C. Harmsen, O. S. Boyd, E. H. Field, R. Chen, N. Luco, R. L. Wheeler, R. A. Williams, A. H. Olsen, and K. S. Rukstales. 2015. Seismic-hazard Maps for the Conterminous United States, 2014: U.S. Geological Survey Scientific Investigations Map 3325, 6 Sheets, Scale 1: 7,000,000. Internet website: http://dx.doi.org/10.3133/sim3325. Accessed July 21, 2015.

Peterson, F. and G. N. Pipiringos. 1979. Stratigraphic Relations of the Navajo Sandstone to Middle Jurassic Formations, Southern Utah and Northern Arizona: Geological Survey Professional Paper 1035–B, 47 p.

Pipiringos, G. N. and R. B. O'Sullivan. 1978. Principal Unconformities in Triassic and Jurassic Rocks, Western Interior United States – A Preliminary Survey. Geological Survey Professional Paper 1035-A, 33 p.

Radbruch-Hall, D. H., R. B. Colton, W. E. Davies, I. Lucchitta, B. A. Skipp, and D. J. Varnes.1982. Landslide Overview Map of the Conterminous United States. Geological Survey Professional Paper 1183, 28 p.

Rasmussen, J. C. 2012. Geologic History of Arizona. Arizona Rocks & Minerals 87(1):56-63.

Reiche, P. 1937. The Toreva-Block – A Distinctive Landslide Type. The Journal of Geology 45(5):538-548.

Rocky Mountain Power. 2010. Utah Public Service Commission Docket Index Docket Number: 10-035-39 Re: 09-035-54; In the Matter of: of the Petition for Review between Rocky Mountain Power and Tooele County for Consideration by the Utility Facility Review Board, Exhibit MMM, Structure Loading Wind and Seismic. Internet website: http://www.psc.utah.gov/utilities/electric/elecindx/2010/1003539indx.html. Accessed December 13, 2011.

Salt River Project Agricultural Improvement and Power District (SRP). 2016. Navajo Project Operation and Maintenance Plan – Final. Revision 9.0, July 23, 2016.

Stewart, J. H. and J. E. Carlson. 1978. Geologic Map of Nevada. Internet website: http://ngmdb.usgs.gov/Prodesc/proddesc_16377.htm. Accessed July 27, 2015.

Tape, C. 2005. The Lower Jurassic Navajo Sandstone: Large-scale Deposition and Small-scale Structures, Glen Canyon Dam. In: Professor J. Kirschvink (editor). Field Trip to Colorado Plateau (southern Utah, northern Arizona, Permian-Triassic Boundary) Ge136c, April 14-18, 2005.

Trapp, R. A. and S. J. Reynolds. 1995. Description: Map Showing Names and Outlines of Physiographic Areas in Arizona used by the Arizona Geological Survey with Base Map Showing Township and Range only. Arizona Geological Survey Open File Report, OFR-95-2b, 1 map sheet, map scale 1:1,000,000. Internet website: http://repository.azgs.az.gov/uri_gin/azgs/dlio/420. Accessed May 13, 2015.

U.S. Geological Survey (USGS). 2015. Search Earthquake Archives. Internet website: http://earthquake.usgs.gov/earthquakes/search/. Accessed July 21, 2015.

U.S. Geological Survey (USGS). 2014. Magnitude/Intensity Comparison. Internet website: http://earthquake.usgs.gov/learn/topics/mag_vs_int.php . Accessed September 10, 2015.

U.S. Geological Survey (USGS). 2012. Earthquake Glossary - Active Fault. Internet website: http://earthquake.usgs.gov/learn/glossary/?term=active%20fault. Accessed February 19, 2016.

U.S. Geological Survey and Arizona Geological Survey . 2006. Quaternary Fault and Fold Database of the United States. Internet website: http://earthquake.usgs.gov/hazards/qfaults/. Accessed July 21, 2015.

U.S. Geological Survey and Nevada Bureau of Mines and Geology. 2006. Quaternary Fault and Fold Database of the United States. Internet website: http://earthquake.usgs.gov/hazards/qfaults/. Accessed July 21, 2015.

Wanek, A. A. and J. G. Stephens. 1953. Geology of the Kaibito and Moenkopi Plateaus and Parts of the Painted Desert, Coconino County, Arizona. U.S. Geological Survey Oil and Gas Investigation Map 145, scale 1:150,000.

Yokel, F. Y. 1990. Earthquake Resistant Construction of Electrical Transmission and Telecommunications Facilities Serving the Federal Government. Federal Emergency Management Agency Report 202, September 1990, 46 p.

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Section 3.4

Mineral Resources

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Acronyms and Abbreviations

1969 Lease	Navajo Project Indenture of Lease
BART	Best Available Retrofit Technology
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BM&LP Railroad	Black Mesa & Lake Powell Railroad
BO	Biological Opinion
CAP	Central Arizona Project
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO_2	carbon dioxide
Co-tenants	Salt River Project, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company
Development Fund	Lower Colorado River Basin Development Fund
EIS	Environmental Impact Statement
ERA	Ecological Risk Assessment
ESA	Endangered Species Act of 1973
HHRA	Human Health Risk Assessment
km	kilometer
KMC	Kayenta Mine Complex
kV	kilovolt
kW	kilowatt
MW	megawatt
N-Aquifer	Navajo Aquifer
NEPA	National Environmental Policy Act of 1969, as amended
NGS	Navajo Generating Station
NGS Participants	U.S. (Reclamation), Salt River Project, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company
NHPA	National Historic Preservation Act
NNEPA	Navajo Nation Environmental Protection Agency
NO_2	nitrogen dioxide
NO_X	nitrogen oxide
OSMRE	Office of Surface Mining Reclamation and Enforcement
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter of 10 microns or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 microns or less
PFR	Partial Federal Replacement
PWCC	Peabody Western Coal Company
Reclamation	U.S. Bureau of Reclamation
ROW	Right-of-way

SO_2	sulfur dioxide
SRP	Salt River Project Agricultural Improvement and Power District
STS	Southern Transmission System
U.S.	United States
USEPA	U.S. Environmental Protection Agency
WTS	Western Transmission System

Contents

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3.4 Mineral Resources

3.4.1 Regulatory Framework

A general definition of mineral resources is “a concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth’s crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible” (U.S. Geological Survey 2016). The following is a list of statutes and rules that apply to mineral extraction:

Surface Mining Control and Reclamation Act of 1977 30 United States Code Subsection 1201 et seq.

- Applies only to surface coal mining.
- The Office of Surface Mining Reclamation and Enforcement is the permitting and enforcement authority.

Mineral Leasing Act of 1920, as amended, 30 United States Code Section 181 et seq. and Federal Coal Leasing Amendments Act of 1976, as amended, 90 Statute 1083-1092 43 Code of Federal Regulations (CFR) 3400:

- Coal Leasing on Federal Lands Exploration License.
- Competitive Lease.
- Lease by Application.

Mining Law of 1872, as amended, 30 United States Code Section 22 et seq. Public Law 167 of 1955, 30 United States Code Section 601 et seq. and Federal Land Policy and Management Act of 1976, 43 United States Code Section 1701 et seq. 43 CFR 3715 and 43 CFR 3802, 3809.

- Governs locatable minerals.

Materials Act of 1947, 30 United States Code Section 601, as amended Public Law 167 of 1955, 30 United States Code Section 601 et seq. and Federal Land Policy and Management Act of 1976, 43 United States Code Section 1701 et seq. 36 CFR 228 Subpart C:

- Mineral Material Contracts Prospecting Permits.
- Free Use Permits.
- Nonexclusive Sales.
- Sale Contracts for Mineral Materials.

Tribal Rules and Regulations

- Navajo Nation; applicable rules of the Navajo Nation Environmental Protection Agency and Division of Natural Resources.
- Hopi Tribe Department of Natural Resources; applicable plans, policies, and ordinances.

3.4.2 Study Areas

3.4.2.1 Proposed Action and Action Alternatives

The study area for mineral resources includes the Navajo Generating Station (NGS) and associated facilities and the proposed Kayenta Mine Complex (KMC). Associated facilities of the NGS include the Black Mesa & Lake Powell (BM&LP) Railroad right-of-way (ROW) that extends from the proposed KMC to the NGS, the coal combustion residuals disposal site, lake pumping station, water pipeline, a 230-kilovolt electrical transmission line, powerlines from the pump station to the NGS, the road between Navajo Nation Route 22B and the pump station, and the coal loadout facility (**Table 1-2, Figure 1-3**). In addition, the study area extends along the maintained ROWs for the transmission systems and communication sites.

3.4.2.2 Cumulative

The cumulative effects study area is the same as the Proposed Action study area because cumulative effects on mineral resources due to the action alternatives are not likely to occur beyond the Proposed Action study area boundary.

3.4.3 Affected Environment

Coal is the primary mineral of interest in the NGS and associated facilities and proposed KMC. There are no commercial oil and gas resources in most of the study area. The Colorado Plateau has been host to exploration and mining of uranium minerals. Uranium mining has occurred in areas on or adjacent to some project facilities. With the exception of one copper mine, precious and base metals are not anticipated mineral resources where project facilities are located.

3.4.3.1 Navajo Generating Station

There are no documented mineral deposits at the NGS site and associated facilities. The Cretaceous coal-bearing units at Black Mesa are not present in the NGS and associated facilities areas, and there are no other coal bearing units. The Kaibito Plateau area is noticeably barren of other mineral resources, including oil and gas, and industrial minerals (Peirce 1987; Rauzi 2015). There also is a low potential for geothermal resources (Conley and Giardina 1979). Precious and base metal occurrences are rare and no mining currently occurs in the area. However, 10 miles south of Page, Arizona, there is a copper occurrence where copper ore was mined intermittently from the 1880s until 1968 (Coppermine Chapter 2015; Yurth 2013). The copper mineralization consists of mainly low-grade malachite, with occasional pockets of higher-grade ore (Read et al. 1943).

The bedrock formations in the study area contain uranium mineralization and former uranium mining sites are present in the northern Arizona area (U.S. Environmental Protection Agency 2015). Uranium was produced at a site a few miles to the southeast of the NGS facility. According the U.S. Environmental Protection Agency (2015), there are many former uranium “production” sites in the northern Arizona range consisting of shallow trenches to pits over 100 feet deep.

3.4.3.2 Proposed Kayenta Mine Complex

The primary mineral resource on the Black Mesa is coal. An early mine was identified by Campbell and Gregory (1909) at Keams Canyon at the southern end of the Black Mesa. This mine produced 2,500 tons of coal in 1908 for local use. Modern mining began in 1970 with the opening of the Black Mesa Mine, which produced 149.6 million tons of coal through 2005 (U.S. Energy Information Agency, 2016; Peabody Western Coal Company [PWCC] 2012 et seq.). The Kayenta Mine opened in 1973 and has produced 305 million tons of coal through 2014. Of the leased reserves of 670 million tons of coal, approximately 455 million tons have been mined through 2014. An additional 100 million tons of coal reserves are available within the lease area should additional tons be needed to be leased in the future (PWCC 2012 et seq.).

No other important mineral resources have been documented on the Black Mesa. Oil and gas test wells have been drilled sporadically, but no commercial resources have been found (Arizona Oil and Gas Conservation Commission 2015). The potential for hydrocarbon production from the Mancos Shale at Black Mesa is unknown because there are no geochemical analyses for total organic carbon content or wells drilled to specifically test the shale (Rauzi 2015; Rauzi and Spencer 2013).Although coalbed natural gas from Cretaceous coal–bearing rocks is a potential resource at Black Mesa, no coalbed natural gas production has been reported (Rauzi 2015). The Wepo and Toreva formations may not be commercially viable for coalbed natural gas due to extensive erosion and canyon cutting resulting in de-gassing of the coals. The Dakota Formation coals may have potential, but have not been tested (Stevens et al. 2002; U.S. Environmental Protection Agency 2013). Minor amounts of scoria, also called clinker, are formed when rocks adjacent to burning coal seams are baked and subjected to thermal metamorphism. The scoria is quarried for road maintenance aggregate and placement in portions of the mined and reclaimed areas to promote medicinal and traditional plant growth (Office of Surface Mining Reclamation and Enforcement 2011).

3.4.3.3 Transmission Systems and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

The mineral resources in the regions crossed by the transmission system corridors and where the communication sites are located consist mainly of industrial minerals including stone, clay, gypsum, limestone, and aggregate (Peirce 1987). Uranium occurrences and production sites are present within and adjacent to the corridors. Oil and gas resources largely are absent.

3.4.3.3.1 Western Transmission System

In the Arizona and Utah portions of the Western (NGS to the McCullough) Transmission System corridor, there are a variety of mineral resources including oil and gas, uranium, base and precious metals, rare earth metals, gypsum, building stone, and aggregate (Bureau of Land Management [BLM] 2007). A few uranium occurrences and prospects appear to be adjacent or near the corridor. In Arizona, portions of the transmission route cross areas that have been withdrawn from mineral entry under the Mining Law of 1872 (BLM 2012). The withdrawal would affect locatable minerals such as uranium and precious and base metals, but would not affect leasable minerals and saleable minerals. In Nevada, mineral resources mainly consist of gypsum, limestone, and aggregate (BLM 2015). There are no coal or oil and gas resources in the Nevada portion of the Western Transmission System.

3.4.3.3.2 Southern Transmission System

There are few mineral resources where the corridor crosses the Kaibito Plateau area as discussed above for NGS and ancillary facilities. About 30 miles south of Page, Arizona, the corridor crosses the Cameron uranium mining area that follows the corridor. The Cameron uranium mining area stretches along U.S. Highway 89 for about 18.0 miles and is about 5.0 miles wide (Chenoweth 1993). The uranium ore was mined from members of the Chinle, Kayenta, and Moenkopi formations. Mining occurred in the area from 1951 to 1963, mostly from excavations and pits. However, some underground mining was conducted and 289,247 tons of ore was mined, which produced 1.2 million pounds of uranium oxide.

South of the Cameron uranium area to Phoenix, the mineral commodities consist of industrial minerals (stone, clay, gypsum) and precious and base metals (Peirce 1987).

3.4.3.3.3 Communication Sites

The mineral resources for the communication sites are generally the same as for the transmission system or facility to which they are associated.

3.4.4 Environmental Consequences

3.4.4.1 Issues

The purpose of the mineral resources section is to assess what impacts would occur to mineral resources as a result of the Proposed Action and alternatives. The specific threshold for impacts is the potential preclusion of access to mineral resources from each of the project components as described in Section 3.4.3. Mineral deposits by their nature are often hidden from immediate detection and it is possible that undiscovered mineral deposits may intersect or lie beneath project facilities. Another potential impact that is specific to the proposed KMC and is whether there are adequate coal resources to provide fuel to NGS.

Issue 1 – Access to Minerals

- Potential for facilities or operations associated with the NGS-KMC to preclude development of other mineral resources.

Issue 2 – Adequacy of Coal Resources

- Adequate coal availability at the proposed KMC for NGS consumption through 2044.

3.4.4.2 Assumptions and Impact Methodology

It was assumed that no field surveys would be conducted to collect data and that data would be acquired from readily available published or government agency sources, academic institutions, or information provided by the NGS Participants and PWCC (Section 3.4.5, References). It also was assumed that the sources used provided reasonable estimates regarding the occurrence and development potential of mineral resources that may be present in proximity to the project components. An exhaustive review of mineral claims or leases was not conducted in the preparation for this analysis and such a review would be outside the scope of the analysis. The description of mineral resources was used to analyze potential impacts.

The methodology for analysis of potential impacts was to review the available data and make a determination whether there is a potential that actions would result in a loss of availability of mineral resources. With regard to the proposed KMC, the stated coal reserves at the mine were compared to potential NGS future consumption.

3.4.4.3 Proposed Action

3.4.4.3.1 Navajo Generating Station

3.4.4.3.1.1 Access to Minerals

There is a low probability that commercially extractable minerals are present in the vicinity of the NGS and associated facilities, including the BM&LP Railroad ROW. Therefore, the Proposed Action for either the 3-Unit Operation or 2-Unit Operation would have negligible impacts on access to minerals.

3.4.4.3.2 Proposed Kayenta Mine Complex

3.4.4.3.2.1 Access to Minerals

There is a low probability that commercially extractable minerals other than coal are present in the vicinity of the proposed KMC. Therefore, impacts due to restriction of access to minerals are negligible.

3.4.4.3.2.2 Adequacy of Coal Resources

The PWCC life-of-mine plan anticipates that there will be adequate coal to meet NGS generation requirements from 2020 through 2044 (Section 2.3.1.2, **Table 2-6**). Coal would be mined from existing and new coal resource areas over this period at the rate of 8.1 million tons per year to support a NGS 3-Unit Operation, or 5.5 million tons per year to support a NGS 2-Unit Operation. There would be no impacts as a result of inadequate coal resources.

3.4.4.3.3 Transmission Systems and Communication Sites

3.4.4.3.3.1 Access to Minerals

There is a low probability that commercially extractable minerals are present within the transmission system corridors and communication sites. Therefore, the Proposed Action for either the 3-Unit Operation or 2-Unit Operation would have negligible impacts on access to minerals.

3.4.4.3.4 Project Impact Summary – All Project Components

Under the Proposed Action, impacts to mineral resource availability from each of the project components are expected to be negligible because of the low probability of commercially extractable minerals in the study area except for coal.

Coal resources at the proposed KMC would be adequate to meet NGS power generation commitments and there would be no impacts from inadequate coal to meet the demands for power generation under the Proposed Action.

3.4.4.3.5 Cumulative Impacts

No reasonably foreseeable actions are expected to occur that would intersect with the study area for minerals defined in Section 3.4.2; as a result, no cumulative impacts would occur.

3.4.4.4 Natural Gas Partial Federal Replacement Alternative

Under the Natural Gas Partial Federal Replacement (PFR) Alternative, a selected quantity of power between 100 megawatts (MW) and 250 MW would be contracted for under a long-term power purchase agreement from currently unidentified, existing natural gas generation sources, displacing an equivalent amount of power from the federal share of NGS generation. Because the facility is assumed to currently exist, prior impacts to mineral resources are not evaluated. The following are key assumptions about resources related to such an existing site:

- Because the site is not known, no site specific evaluation for the presence of mineral resources was performed.
- The site does not present a hindrance to mineral entry.
- Valuable mineral resources are not present.

Impact issues for the Natural Gas PFR Alternative are discussed across the range of NGS unit operations (3-Unit and 2-Unit) and associated alternative power reductions (100 MW and 250 MW) from the least NGS power reduction to the greatest. Reductions in NGS power generation would proportionally reduce the quantity of coal delivered from the Kayenta Mine.

The focus of this discussion is to distinguish differences in impacts within the replacement alternative operational range to provide a basis for comparison with the Proposed Action.

3.4.4.4.1 Navajo Generating Station

3.4.4.4.1.1 Access to Minerals

As with the Proposed Action Alternative, there is a low probability that commercially extractable minerals are present in the vicinity of the NGS and associated facilities, including the BM&LP Railroad ROW. Therefore, the Natural Gas PFR Alternative would have negligible impacts on access to minerals.

3.4.4.4.2 Proposed Kayenta Mine Complex

3.4.4.4.2.1 Access to Minerals

As with the Proposed Action Alternative, there is a low probability that commercially extractable minerals other than coal are present in the vicinity of the proposed KMC. Therefore, impacts due to restriction of access to mineral are negligible.

3.4.4.4.2.2 Adequacy of Coal Resources

Under the Natural Gas PFR Alternative, there would be sufficient coal resources to provide fuel to the plant from 2020 to 2044. Consumption would be less than the coal consumption under the Proposed Action where it is expected that coal resources are adequate to support generation under the 3-Unit Operation or 2-Unit Operation. The Natural Gas PFR Alternative is the lowest coal consuming alternative and the lowest with respect to the 100-MW and 250-MW cases.

3.4.4.4.3 Transmission Systems and Communication Sites

3.4.4.4.3.1 Access to Minerals

There is a low probability that commercially extractable minerals are present within the transmission system corridors and communication sites. Therefore, like the Proposed Action, the Natural Gas PFR Alternative for either the 3-Unit Operation or 2-Unit Operation would have negligible impacts on access to minerals.

3.4.4.4.4 Project Impact Summary – All Project Components

Under the Natural Gas PFR Alternative, impacts to mineral resource availability from each of the project components are expected to be negligible because of the low probability of commercially extractable minerals in the study area except for coal.

Under the Natural Gas PFR Alternative coal resources at the proposed KMC would be adequate to meet NGS power generation commitments and there would be no impacts from inadequate coal to meet the demands for power generation. Consumption would be less than the coal consumption under the Proposed Action and the Natural Gas PFR Alternative represents the lowest coal consuming alternative.

3.4.4.4.5 Cumulative Impacts

No reasonably foreseeable actions are expected to occur that would intersect with the study area for minerals defined in Section 3.4.2; as a result, no cumulative impacts would occur.

3.4.4.5 Renewable Partial Federal Replacement Alternative

Under the Renewable PFR Alternative, a selected quantity of power between 100 MW and 250 MW would be contracted for under a long-term power purchase agreement from a currently unidentified, existing renewable energy power source, displacing an equivalent amount of power from the federal share of NGS generation. Because the facility is assumed to currently exist, prior impacts to mineral resources are not evaluated. The following are key assumptions about resources related to such an existing site:

- Because the site is not known, no site specific evaluation for the presence of mineral resources was performed.
- The site does not present a hindrance to mineral entry.
- Valuable mineral resources are not present.

Impact issues for the Renewable PFR Alternative are discussed across the range of NGS unit operations (3-Unit and 2-Unit) and associated alternative power reductions (100 MW and 250 MW) from the least

NGS power reduction to the greatest. Reductions in NGS power generation would proportionally reduce the quantity of coal delivered from the Kayenta Mine.

The focus of this discussion is to distinguish differences in impacts within the replacement alternative operational range to provide a basis for comparison with the Proposed Action.

3.4.4.5.1 Navajo Generating Station

3.4.4.5.1.1 Access to Minerals

As with the Proposed Action Alternative, there is a low probability that commercially extractable minerals are present in the vicinity of the NGS and associated facilities, including the BM&LP Railroad ROW. Therefore, the Renewable PFR Alternative would have negligible impacts on access to minerals.

3.4.4.5.2 Proposed Kayenta Mine Complex

3.4.4.5.2.1 Access to Minerals

Under the Renewable PFR Alternative there is a low probability that commercially extractable minerals other than coal are present in the vicinity of the proposed KMC. Therefore, impacts due to restriction of access to mineral are negligible.

3.4.4.5.2.2 Adequacy of Coal Resources

Under the Renewable PFR Alternative, there would be sufficient coal resources to provide fuel to the plant from 2020 to 2044 since consumption would still be less than the coal consumption under the Proposed Action where it is expected that coal resources are adequate to support generation under the 3-Unit Operation or 2-Unit Operation.

3.4.4.5.3 Transmission Systems and Communication Sites

3.4.4.5.3.1 Access to Minerals

There is a low probability that commercially extractable minerals are present within the transmission system corridors and communication sites. Therefore, like the Proposed Action, the Renewable PFR Alternative for either the 3-Unit Operation or 2-Unit Operation would have negligible impacts on access to minerals.

3.4.4.5.4 Project Impact Summary – All Project Components

Under the Renewable PFR Alternative, impacts to mineral resource availability from each of the project components are expected to be negligible because of the low probability of commercially extractable minerals in the study area except for coal.

Under the Renewable PFR Alternative coal resources at the proposed KMC would be adequate to meet NGS power generation commitments and there would be no impacts from inadequate coal to meet the demands for power generation.

3.4.4.5.5 Cumulative Impacts

No reasonably foreseeable actions are expected to occur that would intersect with the study area for minerals defined in Section 3.4.2; as a result, no cumulative impacts would occur.

3.4.4.6 Tribal Partial Federal Replacement Alternative

Under the Tribal PFR Alternative, between 100 MW and 250 MW of power generation from the NGS would be replaced by power supplied by a new photovoltaic generation facility on tribal land, displacing an equivalent amount of power from the federal share of NGS generation. The construction of a new photovoltaic generation site on tribal land would result in between 1,200 and 3,000 acres of new surface disturbance. The Tribal PFR facility would be analyzed in a separate National Environmental Policy Act process once a facility location is identified.

3.4.4.6.1 Navajo Generating Station

3.4.4.6.1.1 Access to Minerals

As with the Proposed Action Alternative, there is a low probability that commercially extractable minerals are present in the vicinity of the NGS and associated facilities, including the BM&LP Railroad ROW. Therefore, the Tribal Gas PFR Alternative would have negligible impacts on access to minerals.

3.4.4.6.2 Proposed Kayenta Mine Complex

3.4.4.6.2.1 Access to Minerals

Under the Tribal PFR Alternative there is a low probability that commercially extractable minerals other than coal are present in the vicinity of the proposed KMC. Therefore, impacts due to restriction of access to mineral are negligible.

3.4.4.6.2.2 Adequacy of Coal Resources

Under the Tribal PFR Alternative, there would be sufficient coal resources to provide fuel to the plant from 2020 to 2044 since consumption would still be less than the coal consumption under the Proposed Action where it is expected that coal resources are adequate to support generation under the 3-Unit Operation or 2-Unit Operation.

3.4.4.6.3 Transmission Systems and Communication Sites

3.4.4.6.3.1 Access to Minerals

There is a low probability that commercially extractable minerals are present within the transmission system corridors and communication sites. Therefore, like the Proposed Action, the Tribal PFR Alternative for either the 3-Unit Operation or 2-Unit Operation would have negligible impacts on access to minerals.

3.4.4.6.4 Project Impact Summary – All Project Components

Under the Tribal PFR Alternative, impacts to mineral resource availability from each of the project components are expected to be negligible because of the low probability of commercially extractable minerals in the study area except for coal.

Under the Tribal PFR Alternative coal resources at the proposed KMC would be adequate to meet NGS power generation commitments and there would be no impacts from inadequate coal to meet the demands for power generation.

3.4.4.6.5 Cumulative Impacts

No reasonably foreseeable actions are expected to occur that would intersect with the study area for minerals defined in Section 3.4.2; as a result, no cumulative impacts would occur.

3.4.4.7 No Action

3.4.4.7.1 Navajo Generating Station

3.4.4.7.1.1 Access to Minerals

There is a low probability that commercially extractable minerals are present in the vicinity of the NGS and associated facilities. Therefore, the No Action Alternative would have negligible impacts on access to minerals. Any impacts to access to other mineral resources would be further reduced by the closure and reclamation of the NGS and associated facilities. Thus, if other minerals are found to be commercially extractable, there would be no barrier to development after reclamation of the site.

3.4.4.7.2 Proposed Kayenta Mine Complex

3.4.4.7.2.1 Access to Minerals

Under the No Action Alternative there is a low probability that commercially extractable minerals other than coal are present in the vicinity of the proposed KMC. Therefore, impacts due to restriction of access to mineral are negligible. Any impacts to access to other mineral resources would be further reduced by the closure and reclamation of the proposed KMC. Thus, if other minerals are found to be commercially extractable, there would be no barrier to development after reclamation of the site.

3.4.4.7.2.2 Adequacy of Coal Resources

Under the No Action Alternative, no mining would occur after 2019 and 5,230 to 4,741 acres of coal would not be extracted, unless other markets could be found for the coal and a separate authorization was provided by Office of Surface Mining Reclamation and Enforcement. Adequacy of coal reserves to fuel the NGS would not be a concern and leasing of additional coal areas would not occur.

3.4.4.7.3 Transmission Systems and Communication Sites

3.4.4.7.3.1 Access to Minerals

There is a low probability that commercially extractable minerals are present within the transmission line ROWs and communication sites. Therefore, it is likely that the No Action Alternative would have negligible impacts on access to minerals.

3.4.4.7.4 No Action Impact Summary – All Project Components

The No Action would have negligible impact concerning the availability of mineral resources at NGS and associated facilities, proposed KMC, and the transmission systems and communication sites. Any impacts to access to other mineral resources would be further reduced by the closure and reclamation of the NGS and associated facilities and the proposed KMC. Thus, if other minerals are found to be commercially extractable, there would be no barrier to development after reclamation of these sites.

Under the No Action Alternative, adequacy of coal reserves to fuel the NGS would not be a concern and leasing of additional coal areas would not occur.

3.4.5 References

Arizona Oil and Gas Conservation Commission. 2015. Well Data. Internet website: http://welldata.azogcc.az.gov/. Accessed August 8, 2015.

Bureau of Land Management (BLM). 2015. TransWest Express Final Environmental Impact Statement BLM/WY/PL-15/012+5101, April 2015.

Bureau of Land Management (BLM). 2012. Record of Decision Northern Arizona Withdrawal, Mohave and Coconino Counties, Arizona January 9, 2012. Internet website: http://www.blm.gov/az/st/en/info/nepa/environmental_library/eis/naz-withdraw.html . Accessed February 11, 2016.

Bureau of Land Management (BLM). 2007. Arizona Strip, Grand Canyon-Parashant and Vermilion Cliffs Monuments Proposed Resource Management Plan/Final Environmental Impact Statement. Internet website: http://www.blm.gov/az/st/en/info/nepa/environmental_library/eis/strip_FEIS_07.html . Accessed February 11, 2016.

Campbell, M. R. and H. E. Gregory. 1909. The Black Mesa Coal Field, Arizona In: U.S. Geological Survey, Contributions to Economic Geology, 1909, Part II, Mineral Fuels--Coal and Lignite Bulletin 431-B, p. 229-238.

Chenoweth, W. L. 1993. Geology and Production History of the Uranium Ore Deposits in the Cameron Area, Coconino County, Arizona. Arizona Geological Survey Contributed Report 93-B, 32 p. and 1 map sheet.

Conley, J. N. and S. Giardina, Jr. 1979. Favorable and Potentially Favorable Areas for Hydrocarbon and Geothermal Energy Sources in Northeastern Arizona. Arizona Geological Survey Oil and Gas Publication OG-28 (Originally published as OGCC Report of Investigation RI-7).

Coppermine Chapter. 2015. Coppermine Chapter home page. Internet website: http://coppermine.navajochapters.org/. Accessed August 7, 2015.

Office of Surface Mining Reclamation and Enforcement (OSMRE). 2011. Environmental Assessment: Kayenta Mine Permit (AZ-0001D) Renewal (Navajo County, Arizona). U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement (Western Region). August 2011. 185 pp + appendices.

Peabody Western Coal Company (PWCC). 2012, et seq. Kayenta Complex Permanent Program Permit AZ-0001E. Life-of-Mine Plan Revision. Submitted to OSMRE May 1, 2012. Last updated March 27, 2015.

Peirce, H. W. 1987. Industrial Minerals and Rocks of Arizona In: H. W. Peirce, (editor). Proceedings of the 21st Forum on the Geology of Industrial Minerals. Arizona Bureau of Geology and Mineral Technology; Geological Survey Branch, Special Paper 4, p. 17-23.

Rauzi, S. L. 2015. Oil and Natural Gas Occurrence in Arizona. Arizona Geological Survey Publication OG-35.

Rauzi, S. L. and J. E. Spencer. 2013. A Brief Overview of the Cretaceous Mancos Shale in Northeastern Arizona and its Hydrocarbon Potential. Arizona Geological Survey Open-File Report OFR-13-08 V.1.O, June 2013.

Read, C. B., R. D. Sample, and H. H. Sullwold, Jr. 1943. Copper Deposits of the White Mesa Mining District, Coconino County, Arizona. U.S. Geological Survey Open-File Report 43-24, 18 p.

Stevens, S. H., J. D. Nations, and S. L. Rauzi. 2002. Black Mesa Coal Basin, Northeastern Arizona: An Overlooked Rocky Mountain Coalbed Methane Play. Abstract: American Association of Petroleum Geologists Annual Meeting March 10-13, 2002, Houston, Texas. Internet website: http://www.searchanddiscovery.com/pdfz/abstracts/pdf/2002/annual/SHORT/ndx_43545.pdf.html. Accessed July 19, 2016.

U.S. Energy Information Agency. 2016. Annual Coal Report. http://www.eia.gov/coal/annual/. Accessed April 18, 2016.

U.S. Environmental Protection Agency (USEPA). 2015. Addressing Uranium Contamination on the Navajo Nation. Internet website: http://www.epa.gov/region9/superfund/navajo-nation/abandoned-uranium.html. Accessed August 8, 2015.

U.S. Environmental Protection Agency (USEPA). 2013. Technical Development Document for the Coalbed Methane (CBM) Extraction Industry. Office of Water, Washington, D.C. EPA-820-R-13-009, 68 p. April 2013.

U.S. Geological Survey (USGS). 2016. Mineral Commodity Summaries 2016, Appendix C, Reserves and Resources. U.S. Geological Survey.

Yurth, C. 2013. What Lies Beneath: Navajo Times, January 17, 2013. Internet website: http://navajotimes.com/news/chapters/011713cop.php#.VcShubHnapo. Accessed August 7, 2015.

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Section 3.5

Paleontological Resources

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Acronyms and Abbreviations

1969 Lease	Navajo Project Indenture of Lease
BART	Best Available Retrofit Technology
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BM&LP Railroad	Black Mesa & Lake Powell Railroad
BO	Biological Opinion
CAP	Central Arizona Project
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO_2	Carbon dioxide
Co-tenants	Salt River Project, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company
Development Fund	Lower Colorado River Basin Development Fund
EIS	Environmental Impact Statement
ERA	Ecological Risk Assessment
ESA	Endangered Species Act of 1973
HHRA	human health risk assessment
km	kilometer
KMC	Kayenta Mine Complex
kV	kilovolt
kW	kilowatt
MW	megawatt
N-Aquifer	Navajo Aquifer
NEPA	National Environmental Policy Act of 1969, as amended
NGS	Navajo Generating Station
NGS Participants	U.S. (Reclamation), Salt River Project, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company
NHPA	National Historic Preservation Act
NNEPA	Navajo Nation Environmental Protection Agency
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxide
OSMRE	Office of Surface Mining Reclamation and Enforcement
PM	Particulate matter
PM_{10}	Particulate matter with an aerodynamic diameter of 10 microns or less
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of 2.5 microns or less
PFR	Partial Federal Replacement
PWCC	Peabody Western Coal Company
Reclamation	Bureau of Reclamation
ROW	Right-of-way

SO_2	Sulfur dioxide
SRP	Salt River Project Agricultural Improvement and Power District
STS	Southern Transmission System
U.S.	United States
USEPA	U.S. Environmental Protection Agency
WTS	Western Transmission System

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3.5 Paleontological Resources

3.5.1 Regulatory Framework

The primary statute for the protection of fossils is the Paleontological Resources Preservation Act of 2009, which empowered various federal land management agencies to generate regulations for the protection of fossil resources. The Paleontological Resources Protection Act of 2009, however, does not apply to tribal lands. In order to collect "embedded fossils," or fossils embedded in the rock, a permit is needed from the Bureau of Indian Affairs (BIA) (BIA 2012). Collecting non-embedded fossils does not require a permit from the BIA; however, collecting activities are under the jurisdiction of tribal authorities.

The U.S. Forest Service and the Bureau of Land Management (BLM) also have established regulations and guidance regarding the preservation and collection of fossil resources. The agencies developed a system whereby geologic units can be ranked according to fossil potential as the first step in resource management and protection.

3.5.2 Study Areas

3.5.2.1 Proposed Action and Action Alternatives

The study area for paleontological resources includes the Navajo Generating Station (NGS) and associated facilities, and the proposed Kayenta Mine Complex (KMC) (**Figure 3.3-1**). Associated facilities of the NGS include the Black Mesa & Lake Powell Railroad right-of-way that extends from the proposed KMC to the NGS, the coal combustion residuals disposal site, lake pumping station, water pipeline, a 230-kilovolt electrical transmission line, powerlines from the pump station to the NGS, the road between Navajo Nation Route 22B and the pump station, and the coal loadout silo. (**Table 1-2, Figure 1-3**). In addition, the study area extends along the maintained transmission system corridor right-of-way and communication sites.

3.5.2.2 Cumulative

The cumulative effects study area is the same as the Proposed Action study area since direct and indirect effects on paleontological resources due to the Proposed Action and alternatives are not likely to occur beyond the Proposed Action boundary.

3.5.3 Affected Environment

The Potential Fossil Yield Classification system provides a way to rank geologic units based on the relative abundance of scientifically important fossils (plants, vertebrates, and invertebrates). A higher rank number (listed below) indicates a higher potential for the occurrence of fossils of scientific importance. The Potential Fossil Yield Classification system is not intended to be applied to specific paleontological localities or small areas within units. Although important localities may occasionally occur in a geologic unit, a few widely scattered important fossils or localities do not necessarily indicate a higher class; instead, the relative abundance of significant localities is intended to be the major determinant for the class assignment. The classification should be used to assist in determining the need for further management, including mitigation, assessment, or other actions. Descriptions of the potential fossil yield classes are summarized below (BLM 2013):

- Class 1—Igneous and metamorphic geologic units (excluding tuffs) that are not likely to contain recognizable fossil remains.
- Class 2—Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically important nonvertebrate fossils.

- Class 3—Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence (3a); or unknown potential (3b), but could contain fossils based on geologic features or apparent preservation condition.
- Class 4— Geologic units containing a high occurrence of scientifically important fossils. Proposed ground-disturbing activities would require assessment to determine whether significant paleontological resources occur in an area of proposed disturbance.
- Class 5—Highly fossiliferous geologic units that regularly and predictably produce vertebrate fossils or scientifically important nonvertebrate fossils and that are at high risk of natural degradation or human-caused adverse impacts.

The Potential Fossil Yield Classification is used by the BLM and the U.S. Forest Service for management of fossil resources on lands managed by the respective agencies. The use of the Potential Fossil Yield Classification system here is to provide guidance for assessing paleontological resources regardless of surface ownership or managing agency.

The bedrock in the study area contains formations with high potential for scientifically important fossils. There are numerous sedimentary rock units that have a documented abundance of scientifically important fossils. The discussions in the following sections are intended to be brief summaries of fossil potential and highlights of known fossils in the study area and are not intended to be exhaustive. The Potential Fossil Yield Classification system is used herein because it provides the most effective way to convey the potential for formations to contain fossils and thereby what management measures may be necessary for protection of the resource.

3.5.3.1 Navajo Generating Station

Table 3.5-1 lists the formations that are within the footprint of the NGS and associated facilities and proposed KMC and their Potential Fossil Yield Classification system rankings. The fossil potential of these formations varies greatly from unit to unit. Some formations, like the Morrison Formation, have yielded diverse fauna including vertebrates and invertebrates (Foster et al. 2001). Fossils are rare in the Navajo Sandstone, but track sites have been found in Southern Utah in the Kaiparowits Plateau region.

Table 3.5-1 Potential Fossil Yield Classification Rating NGS and Proposed KMC

Formation/Unit	Age	Potential Fossil Yield Classification Rank
Mesaverde Group	Upper Cretaceous	3
Mancos Shale	Upper Cretaceous	3-5
Dakota Formation	Upper Cretaceous	3-5
Morrison Formation	Upper Jurassic	4-5
Cow Springs Sandstones	Middle Jurassic	ND
Entrada Sandstone	Middle Jurassic	2-3
Carmel Formation	Middle Jurassic	2-3
Page Sandstone	Middle Jurassic	2-3a
Navajo Sandstone	Lower Jurassic	2-3

Source: BLM 2007; Foster et al. 2001; Reppening and Page 1956; U.S. Department of Energy and U.S. Department of the Interior 2008.

ND = Not Determined.

Most of the geologic formations in the study area have low to medium potential, but the Morrison is a high-potential formation that has yielded dinosaur fossils over the entire region. While the Dakota has somewhat medium potential in the analysis area, it has a high potential regionally. The Mancos also is a high-potential formation regionally.

The NGS and associated facilities are underlain by the Navajo Sandstone, Page Sandstone, and Carmel Formation which have low to medium fossil potential as shown in **Table 3.5-1**.

3.5.3.2 Proposed Kayenta Mine Complex

The proposed KMC is primarily underlain by the Cretaceous coal-bearing Wepo Formation of the Mesaverde Group as shown in **Figure 3.3-3**. The coal conveyor located northwest of the coal lease boundary crosses other formations that include the Mancos Shale, Dakota Formation, The San Rafael Group, and the Glen Canyon Group. As shown in **Table 3.5-1**, some of these formations have medium to high potential to contain valuable fossils.

3.5.3.3 Transmission Lines and Communication Sites

The transmission line corridors and communication sites cover a large area with large diversity of geologic units and fossil potential. The descriptions that follow are intended to briefly summarize fossil bearing formations and are not intended to be an exhaustive discussion.

3.5.3.3.1 Western Transmission System

The Western (NGS to McCullough) Transmission System (WTS) (as described in detail in Chapter 1.0) crosses alluvium and unconsolidated valley fill deposits and Paleozoic, Triassic, and Tertiary sedimentary rocks (**Table 3.5-2**) (Arizona Geological Survey 2015; Longwell et al. 1965; Stewart and Carlson 1978). The formations and deposits crossed by the Western Transmission Corridor have low to medium fossil potential.

Table 3.5-2 Potential Fossil Yield Classification Rating Western Transmission System

Formation/Unit	Age	Potential Fossil Yield Classification Rank
Alluvium and unconsolidated materials	Quaternary	2
Horse Spring	Late Eocene to Late Miocene	3
San Rafael Group	Middle to Late Jurassic	2-3
Glen Canyon Group	Early to Middle Jurassic	2-3
Chinle Formation	Upper Triassic	3
Moenkopi	Lower Triassic	3
Kaibab, Toroweep, Coconino	Permian	3
Supai Formation	Pennsylvanian to Permian	2
Bird Spring	Mississippian to Early Permian	2
Monte Cristo	Mississippian	2
Limestone	Late Cambrian to Middle Cambrian	2
Precambrian	Early Proterozoic	1

Source: Arizona Geological Survey 2015; BLM and U.S. Forest Service 2013; U.S. Department of Energy and U.S. Department of the Interior 2008; U.S. Department of Energy and U.S. Department of the Interior 2013.

3.5.3.3.2 Southern Transmission System

Table 3.5-3 lists the geological units that are crossed by the Southern (NGS to Westwing) Transmission System (STS) (as described in detail in Chapter 1.0). The fossil potential classification ranges from low to medium.

Table 3.5-3 Potential Fossil Yield Classification Rating Southern Transmission System

Formation/Unit	Age	Potential Fossil Yield Classification Rank
Unconsolidated	Holocene	1
Unconsolidated surficial deposits	Middle to Late Pleistocene	1
Unconsolidated surficial deposits	Late Pliocene to Early Pleistocene	1
Volcanic rocks	Tertiary, Quaternary, Holocene	1
Older Tertiary sedimentary deposits.	Paleocence to Pliocene	1
San Rafael Group	Middle to Late Jurassic	2-3
Glen Canyon Group	Early Jurassic	2-3
Chinle	Late Triassic	3
Moenkopi Formation	Early and Middle Triassic	3
Kaibab Formation	Permian	3
Redwall Limestone	Mississippian	2
Temple Butte Formation	Middle to Upper Devonian	2
Muav Limestone	Middle Cambrian	2
Bright Angel Shale	Middle Cambrian	2
Tapeats Sandstone	Lower Cambrian	2
Precambrian	Early Proterozoic	1

Source: Arizona Geological Survey 2015; U.S. Department of Energy and U.S. Department of the Interior 2008.

3.5.3.3.3 Communication Sites

Table 3.5-4 list the bedrock formations/geologic units on which the communication sites are located and the Potential Fossil Yield Classification designations. The fossil potential ranges from low to moderate.

Table 3.5-4 Potential Fossil Yield Classification Ratings for Communication Sites

Site Name	Formation/Unit	Age	Potential Fossil Yield Classification Rank
Apex to Crystal	Redwall Limestone and Supai Group	Mississippian to Early Permian	2
Beaver Dam	Redwall	Mississippian	2
Bill Williams	No formation name	Middle Miocene to Pliocene	1
Buckskin Mountain	Toroweap	Early Permian	3
Glen Canyon	Dune sand	Quaternary	1

Table 3.5-4 Potential Fossil Yield Classification Ratings for Communication Sites

Site Name	Formation/Unit	Age	Potential Fossil Yield Classification Rank
Glendale	Muav Limestone	Middle Cambrian to Late Cambrian	2
Jack's Peak	Glen Canyon Group	Early Jurassic	3
Moenkopi	Chinle Formation Shinarump Member	Late Triassic	3
Mount Elden	No formation name	Middle Pliocene to Holocene	1
Mount Francis	Precambrian	Early Proterozoic	1
Navajo	Glen Canyon Group	Early Jurrassic	3
NGS	Glen Canyon Group	Early Jurassic	3
Pipe Springs	Glen Canyon Group	Early Jurassic	3
Preston Mesa	Glen Canyon Group	Early Jurassic	3
Red Mountain	No formation name	Early Miocene to Early Pliocene	1
West Phoenix	Unconsolidated material	Middle to Late Pleistocene	1
Westwing	Unconsolidated material	Middle to Late Pleistocene	1
White Tanks	Precambrian	Early Proterozoic	1
Zilnez Mesa	Glen Canyon Group	Early Jurassic	3

Source: Arizona Geological Survey 2015; U.S. Department of Energy and U.S. Department of the Interior 2008.

3.5.4 Environmental Consequences

3.5.4.1 Issues

Paleontological resources or fossils are the “remains, imprints, or traces of once-living organisms preserved in rocks and sediments. These include mineralized, partially mineralized, or unmineralized bones and teeth, soft tissues, shells, wood, leaf impressions, footprints, burrows, and microscopic remains. Fossils are considered nonrenewable resources because the organisms they represent no longer exist. Thus, once destroyed, a fossil can never be replaced” (Murphey and Daitch 2007). However, some fossils have a greater scientific value than others because of uniqueness or importance in deciphering earth history (dinosaur bones, for example). The destruction of scientifically important fossils, whether deliberate or inadvertent, would be considered a major impact because of the loss of scientific knowledge of the geological history of the earth and the origins and history of life on earth.

The major issue involving paleontological resources is the potential for direct impacts to as yet unidentified valuable paleontological resources. The most likely direct impact to occur would be loss or destruction of scientifically valuable fossils due to ground disturbance. There also are long-term indirect effects that may occur if a fossil locality is known and is exposed to theft and vandalism.

Issue 1 – Destruction of Fossils

- Potential for destruction of scientifically valuable fossils due to ground disturbance.

Issue 2 – Theft and Vandalism

- Potential for theft or vandalism of a known fossil locality.

3.5.4.2 Assumptions and Impact Methodology

It was assumed that no field surveys would be conducted to collect data and that data would be acquired from readily available published or government agency sources or information provided by the NGS Participants and Peabody Western Coal Company. An exhaustive review of sources was not conducted.

The presence of potentially valuable paleontological resources was determined through the use of the Potential Fossil Yield Classification Rating system which relies on identification of geological formations or rock units to provide an estimate of the fossil potential in any given area. A particular unit may have fossil potential that varies widely over geographic areas, so sources and documents were consulted that could provide fossil potential information over the study area. Where possible, the sources that were consulted provided Potential Fossil Yield Classification Rating system designations of the formations within the study area. These sources included BLM and U.S. Forest Service (2013); U.S. Department of Energy and U.S. Department of the Interior (2008); U.S. Department of Energy and U.S. Department of the Interior (2013). Where Potential Fossil Yield Classification Rating classifications were not readily available, other sources were consulted and a Potential Fossil Yield Classification Rating rank was provided based on descriptions of relative fossil abundance. Once the geologic units within the study area were ranked according to fossil yield potential, it was possible to assess the likelihood of potential impacts that may occur. Given a geologic unit with rank of 1, the probability of impacts is greatly reduced, while a ranking of 4 or 5 may warrant protection measures based on the activities that are likely to occur on those high-potential formations. The higher the Potential Fossil Yield Classification Rating rank, the greater probability that a particular geologic unit could contain valuable fossils.

3.5.4.3 Proposed Action

3.5.4.3.1 Navajo Generating Station

3.5.4.3.1.1 Destruction of Fossils

Activities under the Proposed Action would take place primarily on previously disturbed areas at NGS and associated facilities which are not likely to have recoverable paleontological resources. The exception is undisturbed areas that may be within the coal combustion residual disposal facility. Under the 3-Unit Operation scenario, the facility would have to be expanded to handle more coal combustion residual (Salt River Project Agricultural Improvement and Power District 2016). The amount of additional acreage that would be added to the facility is estimated to be 239 acres (Table 3.0-1). However, the possibility remains that the facility would be expanded onto previously undisturbed areas. Also, aerial imagery in conjunction with recent geological mapping shows there are large areas within the facility that exhibit evidence of prior disturbance, but where no coal combustion residuals have been deposited (Billingsley and Priest 2013; Google 2016). The disturbance appears to be water bars or berms that are located on the east side of the facility on a bench topped by the Carmel Formation. Within the disposal area, these are areas that appear to have been graded, but no coal combustion residual has been deposited.

The geologic units that would be affected by potential new disturbance at the coal combustion residual facility are the Navajo and Page Sandstones and the Carmel Formation. These units have Potential Fossil Yield Classification rankings that range from 2 to 3, indicating low to moderate potential for fossils. Given the low to moderate ranking and the probable small amount of actual undisturbed areas within the boundary of the facility, impacts to fossil resources are expected to be negligible. The design of the facility calls for lifts of coal combustion residual that are stacked into drainages or canyons. Although no grading or backfilling would occur on the canyon walls, there is the possibility that fossils could be buried by the lifts that would fill the drainages with coal combustion residual and any fossils would be lost since they would not be readily accessible.

Overall, impacts to paleontological resources are expected to be negligible because of the low to moderate fossil potential of the NGS bedrock formations and limited potential for disturbance of new ground, as ground disturbance is likely to occur in areas that have already been disturbed.

3.5.4.3.1.2 Theft and Vandalism

There would be negligible potential for theft and vandalism of fossil sites because the potential for fossil finds is low to moderate, there are no known fossil localities, and the access to the NGS site would be controlled.

3.5.4.3.1.3 Protection Measures

The following protection measure is recommended for both 3-Unit Operation and 2-Unit Operation.

In the event that activities would result in impacts on fossils not detected previously, work in the area would cease and a qualified professional would evaluate the area. Salt River Project Agricultural Improvement and Power District would work with Reclamation and the BIA for the recovery of important fossils prior to resuming operations. Fossils found on tribal lands are the property of the respective tribes. No other disturbances would be expected to occur outside of previously disturbed areas at the NGS or associated facilities as described in Section 3.5.2.

3.5.4.3.2 Proposed Kayenta Mine Complex

3.5.4.3.2.1 Destruction of Fossils

Ongoing mining activities would have the potential to cause damage or loss of paleontological resources. The Mesaverde Formation has a moderate potential to contain scientifically valuable or important fossils (**Table 3.5-1**). Because fossils are uncommon in the Mesaverde Formation in the Black Mesa area, the potential for destruction of valuable fossils during coal mining is negligible under either the 3-Unit Operation or 2-Unit Operation. The bedrock formations crossed by the coal conveyor to the railroad loadout consist of the Mesaverde Group, Mancos and Dakota formations, the San Rafael Group, and the Glen Canyon Group. The Mancos and Dakota formations have medium to high potential for fossils and the San Rafael and Glen Canyon Groups are medium to low potential. The coal conveyor and associated access road is a previously disturbed area and therefore, impacts to paleontological resources would be negligible.

3.5.4.3.2.2 Theft and Vandalism

In general, there would be negligible potential for theft and vandalism of fossil sites because the potential for fossil finds is moderate within the Mesaverde Formation and there are no known fossil localities.

Where the conveyor crosses the outcrop of the Mancos-Dakota there is a possibility of exposed fossils which could be subject to theft or vandalism. The impacts would be negligible because the access road and conveyor would not be accessible to the public, the terrain limits access, and the outcrops are vegetated and largely covered with colluvium.

3.5.4.3.2.3 Protection Measures

In the event that potentially valuable fossils are encountered during mining or excavation along the coal conveyor, the following measure would be implemented (Office of Surface Mining Reclamation and Enforcement 2011). In the event that mining activities would result in impacts on fossils not detected prior to mining activity, work in the area would cease and a qualified professional would evaluate the area. Peabody Western Coal Company would work with regulatory and tribal officials for the recovery of important fossils prior to resuming mining operations. Peabody Western Coal Company would recover any important fossils discovered during mining operations.

3.5.4.3.3 Transmission Systems and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

3.5.4.3.3.1 Destruction of Fossils

Operation and maintenance activities for the transmission systems under the Proposed Action would take place on previously disturbed areas which are not likely to have salvageable paleontological resources. Therefore, no impacts are expected as long as work is confined to the disturbed right-of-way.

Operation and maintenance activities at communication sites under the Proposed Action would take place on previously disturbed areas which are not likely to have salvageable paleontological resources. Therefore, no impacts are expected.

If work were to occur on undisturbed areas, then the protection measures as described below would be implemented.

3.5.4.3.3.2 Theft and Vandalism

There would be no potential for theft and vandalism of fossil sites since the areas have already been disturbed and no significant fossil locations have been identified.

3.5.4.3.3.3 Protection Measures

If occasional activities take place outside of previously disturbed areas, then prior to conducting work, the Potential Fossil Yield Classification rating of the bedrock in the area should be determined and appropriate protection measures should be implemented if necessary. Such measures could include review and survey by a qualified paleontologist. In the event that operation and maintenance activities would result in impacts on fossils not detected prior, activities would cease and a qualified professional would evaluate the area. The operator would work with the appropriate regulatory officials for the recovery of important fossils prior to resuming operations.

3.5.4.3.4 Project Impact Summary – All Project Components

Impacts to fossil resources for all of the project components would be negligible to none because of the generally low to moderate Potential Fossil Yield Classification rank of the bedrock formations. For the NGS and associated facilities, transmission systems and communication sites most activities would occur in previously disturbed areas with no known fossil locations. The recommended protection measures would provide for the proper documentation and recovery of unanticipated discovery of fossil resources.

The potential for theft and vandalism is negligible to none because of the lack of identified significant fossil locations for any of the project components. In addition, for the NGS and proposed KMC, access would be controlled for most areas limiting the potential for theft and vandalism.

3.5.4.3.4.1 Protection Measures

If occasional activities take place outside of previously disturbed areas, then prior to conducting work, the Potential Fossil Yield Classification rating of the bedrock in the area should be determined and appropriate protection measures should be implemented if necessary. Such measures could include review and survey by a qualified paleontologist. In the event that operation and maintenance activities would result in impacts on fossils not detected prior, activities would cease and a qualified professional would evaluate the area. The operator would work with the appropriate regulatory and tribal officials for the recovery of important fossils prior to resuming operations.

3.5.4.3.5 Cumulative Impacts

No reasonably foreseeable actions are expected to occur that would intersect with the cumulative effects study area for paleontological resources as defined in Section 3.5.2. Since impacts to paleontological resources are expected to be negligible to none under the Proposed Action, no cumulative impacts are expected to occur. Since the transmission lines would continue to operate as presently configured, there would be no new disturbance that would impact fossil resources.

3.5.4.4 Natural Gas Partial Federal Replacement Alternative

Under the Natural Gas Partial Federal Replacement (PFR) Alternative, a selected quantity of power between 100 megawatts (MW) and 250 MW would be contracted for under a long-term power purchase agreement from currently unidentified, existing natural gas generation sources, displacing an equivalent amount of power from the federal share of NGS generation. Because the facility is assumed to currently exist, prior disturbance impacts to paleontological resources are not evaluated. The following is a key assumption about paleontological resources related to such an existing site.

- Loss of paleontological resources may have already occurred due to prior ground disturbance.

Impact issues for this PFR Alternative are discussed across the range of NGS unit operations (3-Unit and 2-Unit) and associated alternative power reductions (100 MW and 250 MW) from the least NGS power reduction to the greatest. Reductions in NGS power generation would proportionally reduce the quantity of coal delivered from the Kayenta Mine.

The focus of this discussion is to distinguish differences in impacts within the replacement alternative operational range to provide a basis for comparison with the Proposed Action.

3.5.4.4.1 Navajo Generating Station

3.5.4.4.1.1 Destruction of Fossils

Impacts to fossil resources would be negligible under the Natural Gas PFR Alternative because of the low to moderate fossil potential of the bedrock formations and limited potential for disturbance of new ground, as ground disturbance is likely to occur in areas that have already been disturbed.

3.5.4.4.1.2 Theft and Vandalism

Indirect effects from theft or vandalism are expected to be negligible because there is a low to medium potential for the occurrence of fossils in areas outside of currently disturbed areas, there are no known fossil localities, and the access to the NGS site would be controlled.

3.5.4.4.1.3 Protection Measures

The protection measures for the NGS under the Natural Gas PFR Alternative would be the same as for the Proposed Action.

3.5.4.4.2 Proposed Kayenta Mine Complex

3.5.4.4.2.1 Destruction of Fossils

Impacts would be negligible since important fossils are not expected in the Mesaverde that is mined. The coal conveyor and associated access road is a previously disturbed area and therefore impacts to paleontological resources would be negligible.

3.5.4.4.2.2 Theft and Vandalism

In general, there would be negligible potential for theft and vandalism of fossil sites because the potential for fossil finds is moderate within the Mesaverde Formation and there are no known fossil localities.

Where the conveyor crosses the outcrop of the Mancos-Dakota there is a possibility of exposed fossils which could be subject to theft or vandalism. The impacts would be negligible because the access road and conveyor would not be accessible to the public and the outcrops are vegetated and largely covered with colluvium.

3.5.4.4.2.3 Protection Measures

The protection measures for the Proposed KMC under the Natural Gas PFR Alternative would be the same as for the Proposed Action.

3.5.4.4.3 Transmission Systems and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

3.5.4.4.3.1 Destruction of Fossils

There would be negligible impacts to the exiting transmission systems and communication sites because no changes in the operations of the WTS, STS, or communications sites would occur due to the implementation of the Natural Gas PFR Alternative.

3.5.4.4.3.2 Theft and Vandalism

There would be no potential for theft and vandalism of fossil sites because the areas have already been disturbed and no significant fossil locations have been identified.

3.5.4.4.3.3 Protection Measures

The protection measures for the Transmission Systems and Communication Sites under the Natural Gas PFR Alternative would be the same as for the Proposed Action.

3.5.4.4.4 Project Impact Summary – All Project Components

Impacts to fossil resources for all of the project components would be negligible to none because of the generally low to moderate Potential Fossil Yield Classification rank of the bedrock formations. For the NGS and associated facilities, transmission systems and communication sites most activities would occur in previously disturbed areas with no known fossil locations.

The potential for theft and vandalism is negligible to none because of the lack of identified significant fossil locations for any of the project components. In addition, for the NGS and proposed KMC, access would be controlled for most areas limiting the potential for theft and vandalism.

3.5.4.4.4.1 Protection Measures

The protection measures as described for the Proposed Action would be the same for the Natural Gas PFR Alternative and would provide for the proper collection and curation of fossil resources.

3.5.4.4.5 Cumulative Impacts

Under the Natural Gas PFR Alternative, no reasonably foreseeable actions are expected to occur that would intersect with the cumulative effects study area for paleontological resources as defined in Section 3.5.2. Because impacts to paleontological resources are expected to be negligible to none under the Natural Gas PFR Alternative, no cumulative impacts are expected to occur. Since the transmission lines would continue to operate as presently configured, there would be no new disturbance that would impact fossil resources.

3.5.4.5 Renewable Partial Federal Replacement Alternative

Under the Renewable PFR Alternative, a selected quantity of power between 100 MW and 250 MW would be contracted for under a long-term power purchase agreement from a currently unidentified, existing renewable energy power source, displacing an equivalent amount of power from the federal share of NGS generation. Because the facility is assumed to currently exist, prior disturbance impacts to paleontological resources are not evaluated. The following is a key assumption about paleontological resources related to such an existing site:

- Loss of paleontological resources may have already occurred due to prior ground disturbance.

Impact issues for the Renewable PFR Alternative are discussed across the range of NGS unit operations (3-Unit and 2-Unit) and associated alternative power reductions (100 MW and 250 MW) from the least NGS power reduction to the greatest. Reductions in NGS power generation would proportionally reduce the quantity of coal delivered from the Kayenta Mine.

The focus of this discussion is to distinguish differences in impacts within the replacement alternative operational range to provide a basis for comparison with the Proposed Action.

3.5.4.5.1 Navajo Generating Station

3.5.4.5.1.1 Destruction of Fossils

Impacts to fossil resources would be negligible under the Renewable PFR Alternative because of the low to moderate fossil potential of the bedrock formations and limited potential for disturbance of new ground, as ground disturbance is likely to occur in areas that have already been disturbed.

3.5.4.5.1.2 Theft and Vandalism

Indirect effects from theft or vandalism are expected to be negligible because there is a low to medium potential for the occurrence of fossils in areas outside of currently disturbed areas, there are no known fossil localities, and the access to the NGS site would be controlled.

3.5.4.5.1.3 Protection Measures

The protection measures for the NGS under the Renewable PFR Alternative would be the same as for the Proposed Action.

3.5.4.5.2 Proposed Kayenta Mine Complex

3.5.4.5.2.1 Destruction of Fossils

Impacts would be negligible because important fossils are not expected in the Mesaverde that is mined. The coal conveyor and associated access road is a previously disturbed area and therefore impacts to paleontological resources would be negligible.

3.5.4.5.2.2 Theft and Vandalism

In general, there would be negligible potential for theft and vandalism of fossil sites because the potential for fossil finds is moderate within the Mesaverde Formation and there are no known fossil localities.

Where the conveyor crosses the outcrop of the Mancos-Dakota there is a possibility of exposed fossils which could be subject to theft or vandalism. The impacts would be negligible because the access road and conveyor would not be accessible to the public and the outcrops are vegetated and largely covered with colluvium.

3.5.4.5.2.3 Protection Measures

The protection measures for the Proposed KMC under the Renewable PFR Alternative would be the same as for the Proposed Action.

3.5.4.5.3 Transmission Systems and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

3.5.4.5.3.1 Destruction of Fossils

There would be negligible impacts to the exiting transmission systems and communication sites because no changes in the operations of the WTS, STS, or communications sites would occur due to the implementation of the Renewable PFR Alternative.

3.5.4.5.3.2 Theft and Vandalism

There would be no potential for theft and vandalism of fossil sites because the areas have already been disturbed and no significant fossil locations have been identified.

3.5.4.5.3.3 Protection Measures

The protection measures for the Transmission Systems and Communication Sites under the Renewable PFR Alternative would be the same as for the Proposed Action.

3.5.4.5.4 Project Impact Summary – All Project Components

Impacts to fossil resources for all of the project components would be negligible to none because of the generally low to moderate Potential Fossil Yield Classification rank of the bedrock formations. For the NGS and associated facilities, transmission systems and communication sites most activities would occur in previously disturbed areas with no known fossil locations. The recommended protection measures would provide for the proper documentation and recovery of unanticipated discovery of fossil resources.

The potential for theft and vandalism is negligible to none because of the lack of identified significant fossil locations for any of the project components. In addition, for the NGS and proposed KMC, access would be controlled for most areas limiting the potential for theft and vandalism.

3.5.4.5.4.1 Protection Measures

The protection measures as described for the Proposed Action would be the same for the Renewable PFR Alternative and would provide for the proper collection and curation of fossil resources.

3.5.4.5.5 Cumulative Impacts

Under the Renewable PFR Alternative, no reasonably foreseeable actions are expected to occur that would intersect with the cumulative effects study area for paleontological resources as defined in Section 3.5.2. Because impacts paleontological resources are expected to be negligible to none under the Proposed Action, no cumulative impacts are expected to occur. Since the transmission lines would continue to operate as presently configured, there would be no new disturbance that would impact fossil resources.

3.5.4.6 Tribal Partial Federal Replacement Alternative

Under the Tribal PFR Alternative, between 100 MW and 250 MW of power generation from the NGS would be replaced by power supplied by a new photovoltaic generation facility on tribal land, displacing an equivalent amount of power from the federal share of NGS generation. The construction of a new photovoltaic generation site on tribal land would result in between 1,200 and 3,000 acres of new surface disturbance. The Tribal PFR facility would be analyzed in a separate National Environmental Policy Act process once a facility location is identified.

3.5.4.6.1 Navajo Generating Station

3.5.4.6.1.1 Destruction of Fossils

Impacts to fossil resources would be negligible under the Tribal PFR Alternative because of the low to moderate fossil potential of the bedrock formations and limited potential for disturbance of new ground, as ground disturbance is likely to occur in areas that have already been disturbed.

3.5.4.6.1.2 Theft and Vandalism

Indirect effects from theft or vandalism are expected to be negligible because there is a low to medium potential for the occurrence of fossils in areas outside of currently disturbed areas, there are no known fossil localities, and the access to the NGS site would be controlled.

3.5.4.6.1.3 Protection Measures

The protection measures for the NGS under the Tribal PFR Alternative would be the same as for the Proposed Action.

3.5.4.6.2 Proposed Kayenta Mine Complex

3.5.4.6.2.1 Destruction of Fossils

Impacts would be negligible because important fossils are not expected in the Mesaverde that is mined. The coal conveyor and associated access road is a previously disturbed area and therefore impacts to paleontological resources would be negligible.

3.5.4.6.2.2 Theft and Vandalism

In general, there would be negligible potential for theft and vandalism of fossil sites because the potential for fossil finds is moderate within the Mesaverde Formation and there are no known fossil localities.

Where the conveyor crosses the outcrop of the Mancos-Dakota there is a possibility of exposed fossils which could be subject to theft or vandalism. The impacts would be negligible because the access road and conveyor would not be accessible to the public and the outcrops are vegetated and largely covered with colluvium.

3.5.4.6.2.3 Protection Measures

The protection measures for the Proposed KMC under the Tribal PFR Alternative would be the same as for the Proposed Action.

3.5.4.6.3 Transmission Systems and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

3.5.4.6.3.1 Destruction of Fossils

There would be negligible impacts to the exiting transmission systems and communication sites because no changes in the operations of the WTS, STS, or communications sites would occur due to the implementation of this alternative. Additional disturbance could occur to an unknown number of acres related to connecting a new photovoltaic generation site on tribal land to the existing transmission system and would be evaluated in a subsequent National Environmental Policy Act action.

3.5.4.6.3.2 Theft and Vandalism

There would be no potential for theft and vandalism of fossil sites because the areas have already been disturbed and no significant fossil locations have been identified.

3.5.4.6.3.3 Protection Measures

The protection measures for the transmission systems and communication sites under the Tribal PFR Alternative would be the same as for the Proposed Action.

3.5.4.6.4 Project Impact Summary – All Project Components

Impacts to fossil resources for all of the project components would be negligible to none because of the generally low to moderate Potential Fossil Yield Classification rank of the bedrock formations. For the NGS and associated facilities, transmission systems and communication sites most activities would occur in previously disturbed areas with no known fossil locations. The recommended protection measures would provide for the proper documentation and recovery of unanticipated discovery of fossil resources.

The potential for theft and vandalism is negligible to none because of the lack of identified significant fossil locations for any of the project components. In addition, for the NGS and proposed KMC, access would be controlled for most areas limiting the potential for theft and vandalism.

3.5.4.6.4.1 Protection Measures

The protection measures as described for the Proposed Action would apply to the other alternatives and provide for the proper collection and curation of fossil resources.

3.5.4.6.5 Cumulative Impacts

Under the Tribal PFR Alternative, no reasonably foreseeable actions are expected to occur that would intersect with the cumulative effects study area for paleontological resources as defined in Section 3.5.2. Because impacts paleontological resources are expected to be negligible to none under the Proposed Action, no cumulative impacts are expected to occur. Since the transmission lines would continue to operate as presently configured, there would be no new disturbance that would impact fossil resources.

3.5.4.7 No Action

3.5.4.7.1 Navajo Generating Station

3.5.4.7.1.1 Destruction of Fossils

Activities under the No Action Alternative would take place on previously disturbed areas and would include decommissioning and reclamation. Therefore, no impacts to paleontological resources would be expected.

3.5.4.7.1.2 Theft and Vandalism

Indirect effects from theft or vandalism are expected to be negligible because there is a low to medium potential for the occurrence of fossils in areas outside of currently disturbed areas, there are no known fossil localities, and the access to the NGS site would be controlled through completion of reclamation.

3.5.4.7.2 Proposed Kayenta Mine Complex

3.5.4.7.2.1 Destruction of Fossils

Under the No Action Alternative, mining activities would cease and the probability of loss or destruction of fossil resources would be reduced. Reclamation activities may pose a risk to fossils; therefore, the protection measures listed above for the Proposed Action should stay in place until active reclamation activities have ceased. Impacts to paleontological resources are expected to be negligible because of the low potential for scientifically important fossils in the Mesaverde Group that is mined and the protection measures in case of unexpected discovery of important fossils.

3.5.4.7.2.2 Theft and Vandalism

In general, there would be negligible potential for theft and vandalism of fossil sites since the potential for fossil finds is moderate within the Mesaverde Formation and there are no known fossil localities.

Where the conveyor crosses the outcrop of the Mancos-Dakota there is a possibility of exposed fossils which could be subject to theft or vandalism which could increase during or after reclamation. The impacts would be negligible because the access road and conveyor would not be accessible to the public until reclamation is complete. In addition, the outcrops are currently vegetated and largely covered with colluvium which would not change during site reclamation, making any potential fossils less visible.

3.5.4.7.2.3 Protection Measures

The protection measures for the Proposed KMC under the No Action Alternative would be the same as for the Proposed Action.

3.5.4.7.3 Transmission Systems and Communication Sites

The NGS transmission system is an established part of the western U.S. transmission grid and supports reliability and delivery of power throughout the region, well beyond the power generated by the NGS. Therefore, under the No Action Alternative it is likely that that one, several, or all of the land owners/managers of the transmission line rights-of-way and communication site leases would renew some portion of the facilities to keep the power grid performing as expected.

In the event it is determined that some or all of the transmission systems and communication site ROWs are not renewed, a lengthy study and permitting process would need to occur before any decommissioning is initiated due to the essential and integral nature of these facilities with the western electric grid. As noted in Section 2.3.3, up to 4,826 acres within and alongside the transmission system corridors could be temporarily disturbed if the entirety of the transmission systems and communication sites were decommissioned and removed.

3.5.4.7.3.1 Destruction of Fossils

Decommissioning activities generally would take place on previously disturbed areas which are not likely to have salvageable paleontological resources. Therefore, no impacts are expected. If work were to occur on undisturbed areas, then the protection measures as described for the Proposed Action would apply. However, the potential for impacts to fossil resources is negligible, even outside of previously disturbed areas. No impacts to paleontological resources at communication sites are expected.

3.5.4.7.3.2 Theft and Vandalism

Indirect effects from theft or vandalism are expected to be negligible because there is a low to medium potential for the occurrence of fossils in areas outside of currently disturbed areas and there are no known fossil localities.

3.5.4.7.3.3 Protection Measures

The protection measures for the transmission systems and communication sites under the No Action Alternative would be the same as for the Proposed Action.

3.5.4.7.4 No Action Impact Summary – All Project Components

Under the No Action Alternative, impacts to paleontological resources are expected to be negligible to none because of prior disturbance and protection measures that would protect loss or damage of the resource during decommissioning and reclamation. Potential impacts from mining disturbance of 5,230 acres to 4,741 acres at Kayenta Mine after 2019 would not occur. Reclamation is expected to take place within previously disturbed areas with no known fossil locations. The recommended protection measures would provide for the proper documentation and recovery of unanticipated discovery of fossil resources.

The potential for theft and vandalism is negligible to none because of the lack of identified significant fossil locations for any of the project components. In addition, for the NGS and proposed KMC, access would be controlled for most areas limiting the potential for theft and vandalism.

3.5.4.7.4.1 Protection Measures

The protection measures as described for the Proposed Action would apply to the No Action and would provide for the proper collection and curation of fossil resources.

3.5.5 References

Arizona Geological Survey. 2015. The Geologic Map of Arizona. Internet website: http://data.azgs.az.gov/geologic-map-of-arizona/#. Accessed July 27, 2015.

Billingsley, G. H. and S. S. Priest. 2013. Geologic Map of the Glen Canyon Dam 30' x 60' quadrangle, Coconino County, Northern Arizona: USGS Scientific Investigations Map 3268, pamphlet 43 p., 3 sheets, scale 1:50,000.

Bureau of Land Management (BLM). 2013. Paleontological Laws & Policy. Internet website: http://www.blm.gov/wo/st/en/prog/more/CRM/paleontology/paleontological_regulations.html. Accessed March 9, 2015.

Bureau of Land Management (BLM). 2007. Draft Resource Management Plan and Environmental Impact Statement. Monticello Field Office, Monticello, Utah. Internet website: http://www.blm.gov/ut/st/en/fo/monticello/planning/draft_rmp_eis0.html. Accessed July 31, 2015.

Bureau of Land Management (BLM) and U.S. Forest Service (USFS). 2013. Final Environmental Impact Statement for the Final San Juan National Forest and Proposed Tres Rios Field Office, Land and Resource Management Plan. Internet website: http://www.fs.usda.gov/goto/sanjuan/planning or http://www.blm.gov/co/st/en/fo/sjplc/land_use_planning.html. Accessed May 5, 2016.

Bureau of Indian Affairs (BIA). 2012. Indian Affairs Manual; Part 59, Chapter 7. Environmental and Cultural Resources Management; Paleontological Resources. Internet website: http://bia.gov/WhatWeDo/Knowledge/Directives/IAM/. Accessed July 29, 2015.

Foster, J. R., A. L. Ttitus, G. F. Winterfeld, M. C. Hayden, and A. H. Hamblin. 2001. Paleontological Survey of the Grand Staircase-Escalante National Monument, Garfield and Kane Counties, Utah. Utah Geological Survey Special Study 99. 98 p.

Google Earth. 2016. https://www.google.com/maps/@36.9092485,-111.34778,2746m/data=!3m1!1e3. Accessed April 21, 2016.

Longwell, C. R., E. H. Pampeyan, and R. J. Roberts. 1965. Geology and Mineral Deposits of Clark County, Nevada. Nevada Bureau of Mines Bulletin 62. 218 pp.

Murphey, P. C. and D. Daitch. 2007. Paleontological Overview of Oil Shale and Tar Sands Areas in Colorado, Utah, and Wyoming. U.S. Department of Energy, Argonne National Laboratory Report Prepared for the U.S. Department of Interior Bureau of Land Management, 468 p. and 6 maps (scale 1:500,000).

Office of Surface Mining Reclamation and Enforcement (OSMRE). 2011. Environmental Assessment: Kayenta Mine Permit (AZ-0001D) Renewal (Navajo County, Arizona). U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement (Western Region). August 2011. 185 pp + appendices.

Repenning C. A. and H. G. Page. 1956. Late Cretaceous Stratigraphy of Black Mesa, Navajo and Hopi Indian Reservations, Arizona. Bulletin of the American Association of Petroleum Geologists 40(2):255-294. February 1956.

Stewart, J. H. and J. E. Carlson. 1978. Geologic Map of Nevada. Internet website: http://ngmdb.usgs.gov/Prodesc/proddesc_16377.htm. Accessed July 27, 2015.

U.S. Department of the Interior (USDOI) and U.S. Department of Energy (USDOE). 2013. TransWest Express Transmission Project Draft Environmental Impact Statement. BLM/WY/PL-13/021+5101, June 2013.

U.S. Department of Energy (USDOE) and U.S. Department of the Interior (USDOI). 2008. Programmatic Environmental Impact Statement, Designation of Energy Corridors on Federal Land in the 11 Western States, Volume II, Appendix N, Potential Fossil Yield Classification (PFYC) for Geologic Formations Intersecting Proposed Corridors under the Proposed Action by State. DOE/EIS 0386. November 2008.

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Section 3.6

Soil Resources

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1 # Acronyms and Abbreviations

1969 Lease	Navajo Project Indenture of Lease
BART	Best Available Retrofit Technology
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BM&LP Railroad	Black Mesa & Lake Powell Railroad
BO	Biological Opinion
CAP	Central Arizona Project
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO_2	carbon dioxide
COPEC	chemical of potential ecological concern
Co-tenants	Salt River Project, Arizona Public Service, NV Energy, and Tucson Electric Power Company
Development Fund	Lower Colorado River Basin Development Fund
EIS	Environmental Impact Statement
ERA	Ecological Risk Assessment
ESA	Endangered Species Act of 1973
HHRA	Human Health Risk Assessment
km	kilometer
KMC	Kayenta Mine Complex
kV	kilovolt
kW	kilowatt
MW	megawatt
N-Aquifer	Navajo Aquifer
NEPA	National Environmental Policy Act of 1969, as amended
NGS	Navajo Generating Station
NGS Participants	U.S. (Reclamation), Salt River Project, Arizona Public Service, NV Energy, and Tucson Electric Power Company
NHPA	National Historic Preservation Act
NNEPA	Navajo Nation Environmental Protection Agency
NO_2	nitrogen dioxide
NO_X	nitrogen oxide
OSMRE	Office of Surface Mining Reclamation and Enforcement
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter of 10 microns or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 microns or less
PFR	Partial Federal Replacement
PWCC	Peabody Western Coal Company
Reclamation	U.S. Bureau of Reclamation

ROW	Right-of-way
SO_2	sulfur dioxide
SRP	Salt River Project Agricultural Improvement and Power District
STS	Southern Transmission System
tpy	tons per year
U.S.	United States
USEPA	U.S. Environmental Protection Agency
WTS	Western Transmission System

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3.6 Soil Resources

3.6.1 Regulatory Framework

No specific federal or tribal regulations regarding soils management are applicable to the components of Navajo Generating Station (NGS) except for general conditions associated with plant site and associated facilities, and Black Mesa and Lake Powell railroad (BM&LP Railroad) decommissioning contained in the 1969 Lease and Lease Amendment No. 1 (or a leasing agreement with the Navajo Nation having similar terms as the 1969 Lease and Lease Amendment No. 1) (**Appendix 1B**).

The management of soils affected by mining is under the jurisdiction of the Office of Surface Mining Reclamation and Enforcement (OSMRE), which implements the Surface Mining Control and Reclamation Act requirements for soil protection and productivity on coal surface mines.

The management of soils on transmission systems, communication sites, and service roads are subject to the requirements of the state, federal, or tribal grantor[1] of the right-of-way (ROW), including Bureau of Land Management (BLM) and U.S. Forest Service management plans, where applicable. The Operation and Maintenance Plan (**Appendix 1B**) provides a summary of soil disturbance activities that may occur within the project study area. The primary activity is infrequent, periodic grading of existing access roads to maintain equipment passage. Graded soils would be applied to the existing road surface (**Appendix 1B**).

3.6.2 Study Areas

The study area for the Proposed Action and Alternatives is defined by existing and proposed surface disturbance. Past and present, as well as future project surface disturbance for both NGS and the proposed Kayenta Mine Complex (KMC) are summarized on **Table 3.0-1.** The cumulative impacts study areas for soils includes the NGS-KMC project components as well as other foreseeable projects which are discussed in Chapter 3.0. The key foreseeable surface disturbance actions that overlap with the NGS-KMC project are the Lake Powell water pipeline and transmission line that would parallel the Western Transmission System (WTS) near the Arizona/Utah border (**Figure 3.0-2**), and several transmission lines in the Las Vegas region that overlap with the WTS corridor (**Figure 3.0-3**).

The study areas for trace metal deposition from NGS stacks, and from proposed KMC mining activities would be the same as those described for the Ecological Risk Assessment (ERA) and Human Health Risk Assessment (HHRA) (**Figures 3.0-4** through **3.0-7**). The majority of the deposition from power plant stacks would occur within 50 kilometers (km) of NGS; the majority of the fugitive dust would be deposited within the proposed KMC lease boundary (Section 3.1, Air Quality).

3.6.3 Affected Environment

A variety of data sources were used to identify the baseline soil characteristics in the surface disturbance and trace metal deposition locations within the study areas. Information on land resource areas was obtained from Natural Resources Conservation Service literature or databases, including the Land Resource Regions and Major Land Resource Areas of the U.S., the Caribbean, and the Pacific Basin, U.S. Department of Agriculture Handbook 296 (U.S. Department of Agriculture, Natural Resources Conservation Service 2006). Previous soil surveys have been conducted across areas proposed for mining at the Kayenta Mine in accordance with Surface Mining Control and Reclamation Act requirements.

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[1] ROWs on Navajo Nation would be subject to the covenant not to regulate, contained in the current lease agreement. This covenant would not apply to the communication site on the Kaibab-Paiute Reservation, or the WTS ROW on the Moapa Paiute Reservation, which is under the jurisdiction of the BLM.

Soil characteristics within the project-specific and cumulative effects analysis areas were characterized and evaluated using the databases included in Soil Survey Geographic Database and/or State Soil Geographic Database (U. S. Department of Agriculture, Natural Resources Conservation Service 2015). Project facilities are located on soils that have formed within the Major Land Resource Areas provided on **Table 3.6-1**.

Table 3.6-1 Soil Types for Project Components

Major Land Resource Areas	NGS[1]	Proposed KMC	WTS and Communication Sites	Southern Transmission System (STS) and Communication Sites
MLRA 35 Colorado Plateau	X	X	X	X
MLRA 30 Mojave Desert	X	X	X	X
MLRA 38 Mogollon Transition	—	—	—	X
MLRA 40 Sonoran Basin and Range	—	—	—	X

[1] Includes the NGS 20-km deposition area and the BM&LP Railroad ROW corridor.

Source: U.S. Department of Agriculture, Natural Resources Conservation Service 2006.

- Major Land Resource Area 35 – Colorado Plateau. The topography of the Colorado Plateau generally consists of gently sloping to strongly sloping plains. Volcanic plugs rise abruptly above the plains and steep scarps or deeply incised canyons occur intermittently. The elevation typically ranges from 4,250 to 4,950 feet above mean sea level, and the mountains range from 8,000 to 10,385 feet above mean sea level. The Colorado Plateau has been structurally uplifted. Soil parent materials consist of shale, sandstone, limestone, dolomite, and volcanic rock. Rock outcrops are extensive. The soils on the plateaus, mesas, hillsides, and fan terraces of the Colorado Plateau range from a few inches to more than 5 feet deep and generally are well drained. Soils in many portions of the Colorado Plateau are subject to high wind and water erosion due to sparse vegetation cover, and steep slopes.
- Major Land Resource Area 30 – Mojave Desert. Broad basins, valleys, and old lakebeds make up most of the Mojave Desert Major Land Resource Area, but widely spaced mountains trending north to south occur throughout the area. Isolated, short mountain ranges are separated by an aggraded desert plain. Long alluvial fans coalesce with dry lakebeds between some of the ranges. Elevations range from 282 feet below mean sea level in Death Valley to 3,950 feet above mean sea level in valleys and basins. Some mountain ranges have peaks that exceed 11,100 feet above mean sea level. The soils in the Mojave Desert Major Land Resource Area primarily formed in alluvial deposits on alluvial fans and valley floors. Recent alluvial fans and remnant alluvial fan terraces typically grade from boulder-strewn deposits and coarse desert pavement near the fan apex to finer grained sands, silts, and clays at the lower ends. Playas are at the lowest elevations in the closed basins. They commonly have wind deposits along their downwind fringes. Water from shallow subsurface flows and surface flows that periodically fill the playa basins evaporates, leaving accumulations of evaporite minerals including salts and borates. Saline and sodic soils are common.
- Major Land Resource Area 38 – Mogollon Transition. The Mogollon Transition Major Land Resource Area consists of mountain ranges, canyons, and structural troughs and valleys. Elevations range from 3,000 to 5,500 feet above mean sea level in most areas and from 5,100 to 7,500 feet above mean sea level in the mountains. Most of this Major Land Resource Area is covered by deep alluvium washed in from the adjacent mountains. These deposits of silt, sand, and gravel occur in drainages, valley floors, and terraces. This Major Land Resource Area is an area of intensive volcanism. Isolated outcrops of granite, andesite, and basalt are common. The

soils in the Mogollon Transition Major Land Resource Area primarily formed in alluvium. They developed from igneous or metamorphic rock. The soils generally range from very shallow to very deep and are well drained to somewhat excessively drained. The primary soil resource concerns are maintenance of the content of organic matter, productivity of the soils, and the hazard of water erosion.

- Major Land Resource Area 40 – Sonoran Basin and Range. Topography in the Sonoran Basin and Range Major Land Resource Area consists of many short, fault-block mountain ranges that trend southeast to northwest and rise abruptly from the smooth or gently sloping desert valley floors. Elevations generally range from 980 to 3,600 feet above mean sea level in most of this area but can occur as high as 4,590 feet above mean sea level in the mountains. Most of this Major Land Resource Area is covered by deep alluvium washed in from the adjacent mountains. These deposits of silt, sand, and gravel occur in drainages, valley floors, and terraces. This Major Land Resource Area is an area of intensive volcanism. Isolated outcrops of granite, andesite, and basalt are common. The soils in the Sonoran Basin and Range primarily formed in alluvium. They developed from igneous or metamorphic rock. The soils generally range from very shallow to very deep and are well drained to somewhat excessively drained. The primary soil resource concern is the absence of soil sustainability, resulting in no soil loss tolerance within this extremely arid environment. Other resource concerns include declining water tables and accumulation of salts in irrigated soils.

3.6.3.1 Navajo Generating Station

3.6.3.1.1 Surface Disturbance

Through 2019, surface disturbance from operation of the NGS and associated facilities, BM&LP Railroad, and coal combustion residuals disposal area and road is estimated to be 3,485 acres (**Table 3.0-1**). Of this total, the majority of the railroad track embankment area, and 107 acres of the west face of the coal combustion residuals disposal area have been revegetated. The remainder of the area is committed to industrial uses with no native soil cover on disturbed surfaces.

3.6.3.1.2 Soil Quality

Limited soil chemistry information, particularly for trace metals and other pollutants are available from published sources for the immediate area around NGS. As a consequence, surface and near-surface soil sampling was conducted in the vicinity of NGS and within the proposed KMC in 2015.

As described in the NGS Sampling Investigation Report (Ramboll Environ 2016f) soil samples were collected within the 20-km deposition radius from the NGS, within the near-field study area. The samples were tested for metals, organics, pH, and acid neutralization potential to characterize current conditions of soils in the vicinity of the NGS. Sampling was conducted in natural communities to provide input to the ERA, and also in the communities of Page and LaChee to provide background for the HHRA. Figure 2-2B in the NGS Sampling Investigation Report (Ramboll Environ 2016f) illustrates the major soil units within the NGS near-field and the soil sampling locations.

Within the NGS near-field area, potential ecological risk associated with emissions that are deposited on terrestrial and aquatic habitats were evaluated through data collected from regional geochemical data bases (Smith et al. 2013) to develop an estimate of the regional background for a variety of constituents including; soil, sediment, and surface water to establish baseline conditions. Baseline conditions refer to the current environmental conditions before any future project activities have taken place. Future project activities begin in 2020. Hazard quotients were calculated for each chemical of potential ecological concern (COEPC). COPECs analyzed in the NGS near-field analysis include inorganic chemicals (metals like mercury and selenium) and organic chemicals, specifically dioxins/furans and polycyclic aromatic hydrocarbons formed during the incomplete burning of coal. Hazard quotients are a ratio of estimated chemical concentrations and the appropriate ecological screening value at or below which impacts to a given species from exposure to a chemical are unlikely. The hazard quotient is not a predictor of risk but rather is an indicator of whether or not there is a potential for risk. Detailed information on how hazard quotients are calculated and how they are interpreted is described in Section 3.0.3, Ecological and Human Health Risk Assessments.

The tiered approach recommended by the U.S. Environmental Protection Agency (USEPA) was adopted in the NGS near-field ERA. “Screening” and “refined” scenarios were used to look at the potential of risk. The screening scenario is a conservative analysis using maximum concentrations of COPECs. The refined scenario is conducted when a potential risk is detected at maximum exposures to COPECs. The refined evaluations consider alternative exposure concentrations, represented by the 95 percent upper confidence limit and average exposure concentrations. This approach is consistent with the USEPA’s Screening Level ERA Protocol, which indicates additional risk assessment calculations can be performed using information more representative of the actual exposure setting rather than the maximum. Hazard quotient value based on the 95 percent refined scenario is considered to be the more realistic indicator of ecological risk rather than the hazard quotient based on maximum exposure. This is because receptors are unlikely to be exposed to the highest levels of all COPECs at all times. For evaluation of soils, if the refined hazard quotient for a given COPEC is less than or equal to one, risk to vegetation and wildlife species, and human receptors from that particular chemical is not likely. If the hazard quotient is greater than one, ecological risk is evaluated further using other lines of evidence.

Table 3.6-2 provides a summary of the regional background concentrations of trace metals based on a large number of samples (Smith et al. 2013), and soil surface sampling that was conducted at multiple locations in the vicinity of NGS.

In general, the metals detected in the soil samples were consistent with regional background soil conditions. Volatile organic compounds were not detected. Total mercury, selenium, and methylmercury were infrequently detected. Arsenic was widely distributed at low concentrations and is considered to be naturally occurring. There were no distinct spatial patterns of compound occurrence or concentrations that would suggest the influence of NGS historic emissions and deposition; thus, the sampling data and concentrations were considered reflective of baseline conditions for the area (Environ 2016g).

The maximum selenium and mercury background soil concentrations would be below USEPA ERA and HHRA screening levels. The maximum background levels of arsenic would be below the USEPA ERA screening level, but above the human health screening level. The evaluation of arsenic in the HHRA at a refined level of analysis (using the 95 percent upper confidence limit) indicated that arsenic did not cause an unacceptable baseline cancer risk to human receptors of all types (Section 3.16, Public Health).

The maximum hazard quotients for baseline (current) conditions were all below one, indicating that there would be no potential for adverse effects to soils under baseline conditions.

Table 3.6-2 Background Soil Trace Metals Data Used for the NGS Baseline Risk Assessments

Chemical	Soil Source/Risk Assessment	Minimum (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	95% UCL (mg/kg)
Arsenic	NGS Near-field (20-km) Samples[1]	0.086	7.1	0.86	1.1
	150 km Background[2]	1.0	31.1	4.88	5.42
	Background for Arizona[2]	1.1	32.0	5.96	6.95
Mercury	NGS Near-field (20-km) Samples[1]	0.0016	0.018	0.0044	0.0053
	150 km Background[2]	0.01	0.04	0.013	0.016
	Background for Arizona[2]	0.01	0.35	0.021	0.023
Methylmercury	NGS Near-field (20-km) Samples[1]	0.00005	0.00041	0.00004	0.00005
	150 km Background[2]	NA	NA	NA	NA
	Background for Arizona[2]	NA	NA	NA	NA
Selenium	NGS Near-field (20-km) Samples[1]	0.059	0.20	0.041	0.033
	150 km Background[2]	0.2	1.0	0.186	0.287
	Background for Arizona[2]	0.2	1.0	0.229	0.237

[1] Field data collected in 2014. Summary values from Table A-2 in the NGS Near-field ERA (Ramboll Environ 2016a), Table A-2D in the San Juan River ERA (Ramboll Environ 2016b), and Table A-2C in the Gap Regions ERA (Ramboll Environ 2016c). Maximum, mean, and 95 percent UCL values used as baseline soil model input values to calculate the hazard quotient maximum, hazard quotient average, and hazard quotient refined values, respectively for the NGS Nearfield ERA (Tables A-4A and A-4B in Ramboll Environ 2016a), San Juan River ERA (Tables A-3A and A-3B in Ramboll Environ 2016b), and Gap Regions ERAs (Tables A-3A and A-3B in Ramboll Environ 2016c).

[2] ERA background summary values from Table 4-2C in the NGS Sampling Investigation Report (Ramboll Environ 2016f).

mg/kg = milligrams per kilograms.

NA = Not available.

ND = Not detected.

UCL=upper confidence limit.

No soil sampling was conducted along the BM&LP Railroad to characterize trace metal concentrations. Particulate coal matter from rail transport is considered to have very little impact outside of the railroad ROW. A single residence lies within 100 meters of the rail line. The large separation distance and restricted access to the rail line make public exposure to coal dust very low (Winges and Steffel 2016).

3.6.3.2 Proposed Kayenta Mine Complex

3.6.3.2.1 Surface Disturbance

The aggregate surface disturbance from coal mining, construction and operation of surface facilities, and infrastructure supporting mining activities (roads, conveyor) on the former Black Mesa Mine, and the Kayenta Mine through 2019 is estimated to be 26,187 acres (Lehn 2016). Of this total, approximately 16,000 acres have been topsoiled and reseeded through 2015. With the exception of Pre-Law lands that did not receive a topsoil material cover, all reclaimed areas under the Initial and Permanent programs conform to Surface Mining Control and Reclamation Act requirements, including regrading so that slope contours approximate the original land form; reapplying soils and soil/overburden mixtures that are suitable for revegetation; and applying revegetation mixtures and plantings to meet future land use goals (**Appendix 1D**, Section 1.3.7). No permanent program areas have received Phase III bond release, which is the final assessment that confirms if reclaimed areas have met the Surface Mining Control and Reclamation Act requirements. See Section 3.14, Land Use, for further information on the ongoing reclamation program and bond release.

3.6.3.2.2 Soil Quality

Soils within the coal resource areas N-9, N-10, N-11 Extension, J-19, J-21, and J-21 West were derived from the Cretaceous Mesaverde Group; a series of sedimentary sandstones, siltstones, and mudstones. In 1979, 1983, 1985, 2000, and 2003, site-specific soil surveys were conducted in accordance with Surface Mining Control and Reclamation Act to provide detailed soil taxonomy and determine thickness of suitable topsoil, subsoil, and unconsolidated material for reclamation use. These surveys identified 14 soils in and surrounding the area. These soils were predominantly very fine- to fine-grained sandy loams with minor smectitic clayey soils. Smectite clays, also referred to as swelling clays, can undergo as much as a 30 percent volume change due to wetting and drying. Soils in the area generally are characterized as well drained with moderate shrink-swell potential and slightly susceptible to wind erosion (OSMRE 2011).

Topsoil is essential for reestablishing native vegetation and forage on reclaimed surface mines. Subsoil and weathered rock overburden beneath the topsoil supply additional nutrients and moisture for plant growth. The removal and replacement of all topsoil is required by Surface Mining Control and Reclamation Act (30 Code of Federal Regulations 816.22) unless it is demonstrated that selected subsoil, weathered overburden, or spoil is better suited for growing plants

During the topsoil salvage process, the top layers are removed and either hauled directly to a reclamation area for reapplication or stored in stockpiles for later use. Studies have shown that the largest disturbance to soils is the initial removal of soils from the site. The top horizon is a highly aggregated, nutrient rich layer, higher in organic matter and microorganisms. The second horizon taken during salvage is typically the same or similar type of soil but consists of less nutrients, organisms, and organic material. When the two layers are stripped, the biological activity of the surface horizon degrades immediately due to mixing with the second, less rich layer.

Stockpiling soils results in reduced infiltration rates and water holding capacity, and a reduction or total loss of organisms such as bacteria, fungi, and small invertebrates (Pranger 2000). Further impacts associated with stockpiling include loss of viable seed communities which promote native vegetation growth and wildlife foraging. Compaction occurs in large stockpiles, reducing oxygen required for respiration at depths of a meter or deeper in the stockpile (Stahl et al. 2000). At depths of one meter or greater in stockpiles, anaerobic bacteria populations increase and aerobic bacteria populations decrease inhibiting nitrification from poor aeration of the soils (Sheoran et al.). Carbon and nitrogen are reduced and soil pH increases in stockpiled soils (Wick et al. 2008). These changes are attributed to the mixing of horizons that occur with the salvaging process.

Direct haul results in the same soil mixing impacts as stockpiling because soil stripping methods are the same. However, direct haul soils provide an immediate revegetation recovery response from the initial disturbance, whereas stockpiled soils must be disturbed a second time when transported for reclamation. Additionally, direct haul soil management allows soils to be placed evenly across an area with depths not generally exceeding one meter. This reapplication approach promotes seed viability, prevents nutrient loss from runoff and erosion and further reductions of carbon and nitrogen.

By definition, topsoil means the A and E soil horizon layers of the four master soil horizons (30 Code of Federal Regulations 701.5). The soils of the proposed KMC have A horizons that range in thickness between 1 inch and 4 inches, depending on the soil. Topsoil may be of insufficient quantity to salvage as a separate layer and must be salvaged together with suitable subsoil and suitable unconsolidated material below the subsoil to provide an average 2-foot-thick topsoil mixture suitable for reclamation.

When a more rocky topsoil material is needed to support the reclamation plan, Peabody Western Coal Company (PWCC) salvages the suitable residual soils unless their depth makes salvage impractical. The soil surveys assess residual soil suitability for reclamation based on seven conditions: selenium concentration, sodic zones, pH, saline strata, texture, rock fragment percentage, and acid-forming spoils.

Graded spoil sampling is an integral part of the reclamation process that ensures a suitable root zone to meet the post-mining land use and that all exposed acid-forming materials are covered. PWCC conducts graded spoil sampling to identify and minimize potentially adverse effects on plant growth and the approved post-mining land use (30 Code of Federal Regulations 715.14 (j), and 816.102(f)). Samples are collected on a grid pattern and analyzed for pH, electrical conductivity, sodium adsorption ratio, percent clay, percent rock fragments, calcium carbonate, and acid-based potential. If maximum thresholds are exceeded for any value indicating that the material could adversely affect plant growth or contribute to toxic levels of elements or compounds in above ground plant parts, the grid is narrowed until the full extent of the potentially unsuitable overburden is determined. Additional overburden/ spoil/topsoil is hauled to cover the area of unsuitable material so that the combination of suitable spoil/overburden and topsoil buries the unsuitable material at least 4 feet. PWCC maintains an inventory of unsuitable graded spoil and suitable soil supplements which is updated on an annual basis. Overall, a 4-foot-thick suitable root zone is created to meet Surface Mining Control and Reclamation Act requirements and reclamation plan goals using a combination of this topsoil mixture underlain with suitable spoil (**Appendix 1D**).

Sodium adsorption ratios over a range of 16 to 40, depending on soil texture, are indicative of elevated sodium in soil, which commonly represents a revegetation constraint (PWCC 2012 et seq.). Overburden materials having elevated sodium adsorption ratios also may have unsuitable pH values: either alkaline pH values greater than 8.8, or acidic pH values less than 5.5. Acidic and acid-forming spoils exist in small localized areas but the graded spoil sampling program mitigates any unsuitable areas by removal or covering to ensure a 4 feet suitable root zone.

Soils in the proposed KMC have the potential for higher than normal selenium concentrations PWCC's geobotanical studies demonstrated that selenium-accumulating plant populations are locally common. The selenium accumulators occurred on the shallow soils associated with wooded ridges and disturbed areas, and were absent from the broad sagebrush valleys and wash terraces where the deeper soils occur. Overburden material, which could be used to provide soil in reclamation areas, also was evaluated for selenium. Initial results indicated the probability of suspect concentrations of plant-available selenium occurring in regraded spoils. Based on the results of selenium analysis in plants and soils at a representative cross section of sites where accumulator plants were found, the soils in which they were growing were not seleniferous. No selenium poisoning of livestock has been reported in or surrounding the Kayenta Mine permit area. Analysis of selenium levels of regraded spoil in comparison to selenium blood levels in cattle grazing on reclaimed areas indicate the selenium levels present in regraded spoil do not pose a threat to livestock and in fact are at or slightly below levels desired for cattle. Selenium supplements are often added to salt blocks used by the local ranchers (OSMRE 2011). Substantial sampling of topsoil, overburden, and reclaimed soil-spoil in 2014 at the proposed KMC indicates selenium levels are low to normal (see **Table 3.6-2** and **Table 3.6-4**).

For the purpose providing data for the ecological and HHRAs, surface and subsurface soil samples were collected within the proposed KMC in the vicinity of residences (Ramboll Environ 2016g); on adjacent lands where special status species may occur; within sensitive areas for the Navajo sedge to the north and northwest of the mine; and sensitive areas for the Mexican spotted owl to the northeast of the mine.

Sixty-five surface soil samples were collected from 59 locations within the proposed KMC study area in 2014. The types of sites and distribution of samples are summarized in **Table 3.6-3**.

Table 3.6-3 Soil Sample Types Collected within the Proposed KMC Study Area

Site Type	Sampling Location and Intensity
Reclaimed areas	Eight surface soil samples were collected from eight locations.
Residential areas	Twenty-one surface soil samples were collected from 19 locations in residential areas.
Topsoil areas	Nine surface soil samples were collected from eight locations in both disturbed and undisturbed areas.
Overburden areas	Eight surface soil samples were collected from eight locations.
Navajo sedge areas	Ten surface soil samples were collected from eight locations in areas supporting the Navajo sedge, a federally listed plant species
Mexican spotted owl areas	Nine surface soil samples were collected from eight locations in areas potentially supporting the Mexican spotted owl.

Table 3.6-4 provides a summary of the trace metal concentration results of regional background studies, as well as recent sampling for key trace metals and other chemicals at the 59 sampling locations.

Table 3.6-4 Soil Trace Metals Data Used for the Proposed KMC Baseline Risk Assessments

Chemical	Soil Source/Risk Assessment	Minimum (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	95% UCL (mg/kg)
Arsenic	Proposed KMC ERA[1]	0.12	10	3.01	3.49
	Proposed KMC Resident HHRA[2]	1.05	9.03	3.39	4.11
	150 km Background[3]	1.0	13.8	3.82	4.22
	Background for Arizona[3]	1.1	32	5.96	6.95
Mercury	Proposed KMC ERA[1]	0.002	0.219	0.029	0.046
	Proposed KMC Resident HHRA[2]	0.008	0.092	0.027	0.034
	150-km Background[2]	0.01	0.04	0.011	0.013
	Background for Arizona[2]	0.01	0.35	0.021	0.023
Methylmercury	Proposed KMC ERA[1]	0.00003	0.0016	0.0002	0.0002
	Proposed KMC Resident HHRA [2]	0.00004	0.0016	0.0003	0.0007
	150-km Background[2]	NA	NA	NA	NA
	Background for Arizona[2]	NA	NA	NA	NA

Table 3.6-4 Soil Trace Metals Data Used for the Proposed KMC Baseline Risk Assessments

Chemical	Soil Source/Risk Assessment	Minimum (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	95% UCL (mg/kg)
Selenium	Proposed KMC ERA[1]	ND	ND	ND	ND
	Proposed KMC Resident HHRA[2]	ND	ND	ND	ND
	150-km Background[2]	0.2	1.0	0.14	0.25
	Background for Arizona[2]	0.2	1.0	0.23	0.24

[1] Field data collected in 2014. Summary values from Table A-2 in the KMC ERA (Ramboll Environ 2016g). Minimum and maximum concentrations were determined from detected concentrations; means were calculated using one-half method detection limit for non-detected chemicals. Maximum, mean, and 95 percent upper confidence limit values used as baseline soil model input values to calculate the hazard quotient maximum, hazard quotient average, and hazard quotient refined values, respectively for the KMC ERA (Tables A-4A and A-4B in Environ 2016g).

[2] Summary values calculated from residential sample values as presented on Table 4-1A in the KMC Sample Investigation Report (Ramboll Environ 2016g). Calculated 95 percent UCL values were used as baseline model input values to calculate the Resident hazard quotient values for the KMC HHRA (Table 6 in Flatirons Toxicology 2015).

[3] Summary values from Table 4-2A in the KMC Sample Investigation Report (Ramboll Environ 2016g). Minimum and maximum concentrations were determined from detected concentrations; means were calculated using one-half MDL for non-detected chemicals.

mg/kg = milligrams per kilograms.

NA = Not available.

ND = Not detected.

Key chemicals were detected at low concentrations and dispersed throughout the proposed KMC study area with no distinct patterns of occurrence, and reflect baseline conditions for the area. Arsenic and total mercury were found to be widely distributed across the study area at low concentrations. Selenium was not detected in surface soils, and methylmercury and total polycyclic aromatic hydrocarbons were infrequently detected (Ramboll Environ 2016g).

A prime farmland assessment was conducted across all lands proposed for surface mining. The soils that occur predominantly are in the Natural Resources Conservation Service land capability Classes VI and VII. Soils in Classes VI and VII have severe to very severe limitations that make them unsuitable for cultivation and limit or restrict their use largely to pasture, range, woodland, or wildlife habitat. Soils in these groupings are primarily used for livestock grazing. The land in the proposed KMC study area has received a negative determination as prime or unique farmland from the Natural Resources Conservation Service (OSMRE 2011).

3.6.3.3 Transmission Systems and Communication Sites

The transmission systems cross, and communication sites are sited on soils that have formed within the four Major Land Resource Areas. Soils located along established transmission lines and communication sites were disturbed for facility construction approximately 40 years ago. Based on an aerial photography review, the majority of the transmission system ROWs have revegetated to a native vegetation community comparable to adjacent undisturbed vegetation communities. Total surface disturbance from construction of transmission lines, substations, switchyards, and access roads is estimated to be 22,964 acres (**Table 3.0-1**). Because of continued use, access roads have not been revegetated. Prior disturbed areas within the transmission system ROW or communication sites would not require redisturbance, and are not expected to incur extensive disturbance associated with maintenance activities as outlined in the Navajo Project Operation and Maintenance Plan (**Appendix 1B**). **Table 3.6-5** summarizes each transmission system and the miles crossed through each Major Land Resource Area. Section 3.6.2 gives a brief description of these Major Land Resource Areas.

Table 3.6-5 Major Land Resource Areas Intersected by the WTS and STS

Major Land Resource Area	WTS Intersected (miles)	STS Intersected (miles)
Major Land Resource Area 30, Mojave Desert	149.1	—
Major Land Resource Area 35, Colorado Plateau	126.1	111.9
Major Land Resource Area 38, Mogollon Transition	—	75.1
Major Land Resource Area 40, Sonoran Basin and Range	—	68.6

3.6.4 Environmental Consequences

3.6.4.1 Issues

Two soil issues are associated the Proposed Action and project alternatives.

Issue 1 – Surface Disturbance/Erosion

- Soil loss and mixing as the result of surface disturbance from new facility construction and mining; risk of unprotected soil erosion from wind and water.

Issue 2 – Trace Metals Deposition from NGS Stack Emissions or from Suspended Particulates

- Deposition of trace metals (primarily from NGS stack emissions, and dust from the proposed KMC onto the soil surface), which then may serve as a source for tissue bioaccumulation in humans, aquatic organisms, terrestrial plants, and terrestrial animals, leading to varying levels of toxicity.

3.6.4.2 Assumptions and Impact Methodology

The following assumptions were used to evaluate project impacts.

- For any new project surface disturbance activity suitable soils will be stripped, stockpiled, replaced over the disturbed area, and revegetated using plant species that are appropriate for the land use and for maintaining soil stability in accordance with Navajo Nation lease agreements for NGS; and the proposed KMC in accordance with PWCC's approved reclamation plan (PWCC 2012 et seq.) and Surface Mining Control and Reclamation Act requirements administered by OSMRE.
- Disturbed soils will be protected against wind and water erosion during the revegetation period using best management practices outlined in **Appendices 1B** and **1D**.
- New soil surface disturbance was calculated from the area of initial disturbance plus a small additional buffer to account for potential soil erosion. The assumptions for buffers on linear facilities (roads, transmission lines, pipelines) are provided in the footnotes to **Table 3.0-1**.
- The entire area of the proposed KMC coal resource areas was assumed to be disturbed to account for pit access roads, soil stockpiles, and overburden placement beyond the mine pit boundaries.

3.6.4.3 Proposed Action

3.6.4.3.1 Navajo Generating Station

3.6.4.3.1.1 Surface Disturbance/Erosion

No new soil disturbance would be required within areas that were previously cleared for plant site construction and operation. These areas include all power generation facilities within the plant site boundary, coal storage areas, wastewater ponds, and landfills. While additional water processing ponds may be added in the future, they would be located entirely within previously graded areas. No additional soil disturbance would be required for the water supply pump station, and the pipeline, road, and transmission line that connect the pump station to the plant site (**Appendix 1B**). Power plant operations would result in new direct soil impacts primarily where soil would be stripped and stockpiled at the coal combustion residuals landfill, as follows:

<u>Coal Combustion Residuals Disposal Area</u>

Soils overlying the coal combustion residuals landfill site primarily consist of unconsolidated sands with minimal soil horizon development. Soil material from approximately 200 additional acres may be stripped, stockpiled, and reapplied from 2020 to 2044 for use in the landfill under the 3-Unit Operation. If 3 units operated through 2044, current coal combustion residuals landfill capacity would be exceeded (**Appendix 1B**, Figure 25). As a consequence, the landfill would be enlarged to accommodate the additional ash. It is assumed that the surface area of the expansion would be 20 percent larger than the area remaining after 2019, or 40 acres. If the 2-Unit Operation were implemented, approximately one-third less coal combustion residuals would be placed in the landfill and no enlargement of the existing landfill footprint would be necessary.

Excavated and graded soils would be protected in accordance with procedures outlined in the Navajo Project Operation and Maintenance Plan (**Appendix 1B**). Erosion control measures would be implemented to ensure soil does not leave the coal combustion residuals landfill or rest of the plant site by water erosion. NGS would implement fugitive dust suppression best management practices (e.g., maintaining road stabilization material and watering soils during earth moving activities) to minimize soil wind erosion (**Appendix 1B**).

Soil contamination could occur during operating and maintenance activities due to chemical storage, fuel or lubricant spills. If spills were to occur, they would result in localized impacts and could require removal of contaminated soils. All operation and maintenance activities would follow the procedures in the Operation and Maintenance Plan including but not limited to compliance with a Spill Prevention, Control, and Countermeasure Plan for all NGS an associated facilities (**Appendix 1B**).

<u>BM&LP Railroad</u>

The railroad would continue operations, and the surface footprint would not be enlarged during the period 2020 to 2044. Operation and maintenance activities would occur within the existing ROW in previously disturbed areas, and may include improvements to the electrical system, track repairs, and improvements at road and natural drainage crossings.

<u>Decommissioning</u>

The NGS would be decommissioned at the end of its operational life, which would require demolition and removal of some of the existing structures and recycling or placement of demolished material in landfills on-site or potentially in approved locations off-site. Structures that would remain include the water supply pump station and pipeline; administration and visitor's buildings; machine, welding, and electric shops and warehouses; existing roads and fences (**Appendix 1B**).

The existing surface disturbance footprint would not be enlarged. As required in the lease, the land would be restored as closely as possible to its original condition. The areas that do not contain permanent facilities would have all nonindigenous material removed from the surface, the area would be filled and graded in order to provide proper drainage but there would be no attempt to return the leased lands or the ROWs to the preconstruction elevations. All restored land would be covered with topsoil indigenous to the area, and revegetated with native plants in order to meet the lease requirements.

Decommissioning of the BM&LP Railroad would include removal of track and the overhead electrical system. The railroad tracks would be removed, but the existing embankments would remain in place. The specific demolition sequence has not been determined, but several options are available. The Decommissioning requirements as described above for NGS are the same for the railroad ROW.

Potential soil and wind erosion would be subject to existing intensive surface management programs for both site erosion control and sedimentation, and for maintenance of short- and long-term stability of the surface cover over the coal combustion residual landfill. During decommissioning, the majority of the plant site would be regraded, topsoil materials applied, and the site reseeded by the end of 2046. In the long term, the site would be slowly revegetated in response to low annual precipitation. The impacts of these activities across the operating range of the Proposed Action would be moderate because new surface disturbance and surface restoration during decommissioning would be at a large scale (3,684 to 3,724 acres) but would be managed in accordance with soil resource protection measures required under Navajo Nation lease terms.

3.6.4.3.1.2 Trace Metals Deposition from NGS Stack Emissions

Power plant stack emissions release particulates to the air which are deposited onto the soil surface at varying distances from the source. The deposition of these metals over time onto soils is information needed to conduct ERA and HHRAs. Deposition is expressed in milligrams of trace metals per kilogram of soil. These estimates for the 2020-2044 operating period were developed from the near-field AERMOD air quality modeling (Environ 2016a) and are shown on **Table 3.6-6**. The majority of the trace metal deposition would occur within 50 km of NGS. The trace metal deposition concentrations divided by background soil concentrations range from less than 1 percent for arsenic; 1 to 2 percent for total mercury; and 4 to 6 percent for selenium. The fate of trace metals deposited on the soil surface could take a number of pathways: they could be further dispersed by wind in dust; could become bound in the surface soil; could move deeper into the soil profile in a soluble form; or could be taken up by plant roots depending on the ionic state of the metal.

Table 3.6-6 Trace Metal Deposition Comparison to Background Concentrations within NGS Study Area

Pollutant	3-Unit Operation (mg/kg)[1]	2-Unit Operation (mg/kg)[2]	Background Concentration 95%UCL (mg/kg)[3]	Deposition Concentration/ Background Concentration (percent)
Arsenic	0.00106	0.00094	1.1	0.096%- 0.085%
Mercury (total)	0.00079	0.00054	.046	1.7%-1.1%
Selenium	0.00202	0.00137	.033	6.1%-4.1%

[1] Appendix B-1 Food Web Input Parameters for B2 (3 Unit) Maximum Concentrations for All Media (Surface Water, Sediment and Soil). Page 233, Ramboll Environ 2016a.

[2] Appendix A-1 Food Web Input Parameters for A1 (2 Unit) Maximum Concentrations for All Media (Surface Water, Sediment and Soil). Page 233, Ramboll Environ 2016a.

[3] Ramboll Environ (2016f).

Soil deposition from NGS stacks, combined with background soil concentrations would be below USEPA ERA and HHRA screening levels for selenium and mercury. The background levels of arsenic would be below the USEPA ERA screening level, but above the human health screening level. The evaluation of arsenic in the HHRA at a refined level (95 percent upper confidence limit) indicated that arsenic did not cause an unacceptable baseline cancer risk to human receptors of all types, and the contribution from NGS under all alternatives is very small, and would not change the conclusion that the cancer risks were within acceptable USEPA levels (Section 3.16, Public Health). Based on AERMOD modeling, and the ERA and HHRAs, impacts of trace metal deposition from the NGS stacks would be minor.

3.6.4.3.2 Proposed Kayenta Mine Complex

3.6.4.3.2.1 Surface Disturbance/Erosion

Under the Proposed Action all mining through the life-of-mine would occur within the proposed KMC. Vegetation clearing, topsoil removal, and mining methods would continue as described for the existing operations (PWCC 2012 et seq.). Additional topsoil stockpiles and additional drainage and sediment control structures would be added as mining progresses (PWCC 2012 et seq.). Disturbed areas would be restored to approximate landforms that existed prior to mining and would support vegetation similar to surrounding areas. As discussed previously, reclamation procedures would create a suitable 4-foot thick plant root zone over the entire reclaimed area and establish a diverse and permanent vegetation cover.

Mining under the Proposed Action would result in a disturbance range of 5,230 acres for the 3-Unit Operation to 4,741 acres under the 2-Unit Operation. All areas disturbed in the future would be subject to bond release through OSMRE. The time frame for all reclaimed areas to meet revegetation standards and be released back to the Navajo Nation or Hopi Tribe likely would require 10 to 15 years after mining ceases.

The impacts of surface coal mining would be moderate because of the relatively large area of new surface disturbance (ranging from 5,230 acres under an 8.1 million ton per year operation to 4,741 acres under a 5.5 million ton per year operation). The potential loss of soil materials from wind and water erosion over the short term (1 to 5 years) would be reduced by intensive surface management programs for soil salvage, soil erosion control, sedimentation control, and revegetation (**Appendix 1D**, Section 1.3). In the long term (5 to 10 years or longer) revegetated areas must meet performance standards for vegetation cover and diversity to achieve bond release. These standards also would serve to insure that soils are stabilized. Over the long term, soil productivity and stability should exceed premining conditions (OSMRE 2011, 2008).

3.6.4.3.2.2 Trace Metal Deposition from Suspended Particulates (Dust)

Mining activities (overburden and coal excavation, blasting, trucks traversing haul roads) release particulates to the air which are deposited onto the soil surface at varying distances from the source. Estimates for the 2020-2044 operating period were developed from the near-field air quality modeling (Ramboll Environ 2016h) and deposition modeling by McVehil-Monnett Associates, Inc. (2016). The majority of the trace metal deposition would occur within the proposed KMC boundary. The air quality modeling includes deposition contributions from NGS on proposed KMC soils because of the high NGS stacks that result in long range dispersal, prevailing winds from the west toward the proposed KMC, and short distance between sources (80 miles) (Section 3.1); proposed KMC particulates are not predicted to reach NGS because particulate generation occurs close to the ground and is localized, and the proposed KMC is downwind of NGS.

The trace metal deposition over the 2020-2044 operating period divided by background soil concentrations range from 4 percent for total mercury, and between 4.6 and 5 percent for selenium and arsenic (**Table 3.6-7**).

Based on AERMOD modeling, impacts of trace metal deposition from particulates would be minor. Particulate deposition, combined with background soil concentrations would be below USEPA ERA and HHRA screening levels for mercury and selenium. The background levels of arsenic would be below the USEPA ERA screening level, but above the human health screening level. The evaluation of arsenic in the HHRA at a refined level (95 percent UCL) indicated that arsenic did not cause an unacceptable baseline cancer risk to human receptors of all types, and the contribution from NGS is small (5 percent) (Section 3.16, Public Health).

Table 3.6-7 Trace Metal Deposition Comparison to Background Concentrations within the Proposed KMC Study Area

Pollutant	3-Unit NGS Operation- 8.1 million tpy Coal (mg/kg)	2-Unit NGS Operation- 5.5 million tpy Coal (mg/kg)	Background Concentration 95%UCL (mg/kg)	Deposition Concentration/ Background Concentration (percent)
Arsenic	0.175	0.171	3.49 [1]	5%-4.8%
Mercury (total)	0.00195	0.00189	.046[1]	4.2%-4.1%
Selenium	0.0117	0.0114	.025[2]	4.7%-4.6%

[1] Samples taken within proposed KMC lease boundary used for ERA inputs.

[2] Samples taken within proposed KMC lease boundary were non-detect for selenium; background represents area within 150 km of the proposed KMC.

3.6.4.3.3 Transmission Systems and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

3.6.4.3.3.1 Surface Disturbance/Erosion

Any surface disturbing activities along the transmission ROWs for operations or maintenance would result in vegetation removal and exposure of small areas of soil to wind and water erosion. These activities would occur intermittently, and impacts would be localized to areas where maintenance occurs. Operators of the WTS and STS would implement committed measures to minimize soil erosion impacts (e.g., avoiding working in wet soils to avoid ruts and erosion as feasible; see **Appendix 1B**). Any new surface disturbance off existing access roads would require separate approval by the land management agency or land owner.

Soil contamination could occur during maintenance activities due to fuel or lubricant spills. If spills were to occur along the ROW, they would result in localized impacts and could require removal of contaminated soils. All operation and maintenance activities would follow the spill prevention procedures in the Operation and Maintenance Plan (**Appendix 1B**).

Traffic on surface access roads during transmission line operations would result in soil compaction or rutting if soils are saturated. Rutting occurs when the soil strength is not sufficient to support the applied load from vehicle traffic. Rutting diverts and concentrates water flows and could cause accelerated erosion and sedimentation to connected waterbodies. Permanent access roads without adequate erosion controls or proper maintenance would degrade and erode. However, as noted above the operators would work to minimize work during wet period to minimize rutting and erosion. Road maintenance provisions are included in the Navajo Project Operation and Maintenance Plan (**Appendix 1B**) for both the WTS and STS.

No additional surface disturbance to maintain existing communications sites is expected.

The impacts to soils would be minor because of the small expected new surface disturbance required for transmission line and communication site repairs, and existing federal agency required measures and project proponent commitments to reduce road damage during wet conditions, and to avoid alteration of existing drainage patterns that could cause sedimentation outside the access road ROW (**Appendix 1B**).

3.6.4.3.4 Project Impact Summary – All Project Components

Impacts from the combined NGS and proposed KMC new soil disturbance from 2020 to 2044 would be moderate because a relatively large area would be disturbed (ranging from 5,230 acres under a NGS 3-Unit Operation to 4,741 acres under the 2-Unit NGS Operation) (**Table 3.0-1**). The salvage and protection of soil would be conducted in accordance with Navajo Nation lease terms for NGS, and in accordance with Surface Mining Control and Reclamation Act regulations and standards administered by OSMRE. WTS and STS transmission operation and maintenance activities would contribute very little new surface disturbance (likely less than 100 acres) over the 2020-2044 operating period. By 2044, assuming NGS and Kayenta Mine closure and demolition, up to 3,724 acres that includes the NGS plant site, railroad, and coal combustion residual landfill would require reapplication of soil materials and revegetation after demolition; a range of 9,000 to 10,000 acres of proposed KMC mined area and demolished surface facilities would require topsoiling and reseeding.

Impacts from selenium and mercury deposition from both NGS and the proposed KMC would be minor because predicted trace metal deposition over the 2020-2044 operating period would be localized (primarily within 50 km of NGS, and within the proposed KMC lease boundary) and would not exceed applicable USEPA screening levels. Arsenic background levels at both NGS and the proposed KMC exceed the human health screening levels. The evaluation of arsenic in the HHRA at a refined level (95 percent UCL) indicated that arsenic did not cause an unacceptable baseline cancer risk to human receptors of all types; the NGS contribution is small (5 percent), and would not change conclusion that the cancer risks were within acceptable USEPA levels (Section 3.16, Public Health).

3.6.4.3.5 Cumulative Impacts

3.6.4.3.5.1 Surface Disturbance/Erosion

The total estimated surface disturbance for past and present actions, proposed action, and reasonably foreseeable future actions is between 62,514 and 61,985 acres (**Table 3.0-1**). By 2044, assuming NGS and Kayenta Mine closure and demolition, up to 3,724 acres that includes the NGS plant site, railroad, and coal combustion residual landfill would require reapplication of soil materials and revegetation after demolition; a range of 9,000 to 10,000 acres of proposed KMC mined area and demolished surface facilities would require topsoiling and reseeding. No new revegetation actions would be required on transmission line ROWs because these ROWs are already vegetated, and would continue operations into the future. Reapplied soils to disturbed areas after 2044 would be protected under the same lease provisions, and bond release programs that existed prior to project termination

Approximately 4,200 acres of reasonably foreseeable surface disturbance from linear utility projects are included in the overall cumulative impact estimate. The TransWest Express, Southern Nevada Intertie, and Eastern Nevada transmission lines may be constructed in an existing West-Wide ROW adjacent to the WTS from the vicinity of Mesquite to the Eldorado Valley south of Las Vegas, Nevada (**Figure 3.0-3**). Segments of the Lake Powell water pipeline and transmission line are proposed to overlap with the WTS utility corridor in Coconino County, Arizona west of Lake Powell (**Figure 3.0-2**). All new surface disturbance would be subject to soil protection measures mandated in ROW conditions received from the BLM or Tribe.

The primary potential cumulative impacts to soils would be the overlapping use of existing access roads by construction and maintenance equipment for adjacent utility projects sharing the same broadly defined utility corridor. For example, the TransWest Express Plan of Development indicates it would use existing utility corridor roads with short spur roads for transmission line structure construction and operation. There could be some localized minor additional soil disturbance from WTS operation and maintenance activities, if the twice yearly inspections occur on the same access routes during periods of construction by these foreseeable projects. Any specific proposals to construct new projects and maintain existing facilities would be coordinated through the responsible BLM or other federal and tribal land management agency offices in Nevada and Arizona. Requirement for new roads, maintenance of existing roads, and repair of damaged roads would be developed on a project-specific basis. The net result would be reduced requirements for new access roads in a common utility corridor, which would reduce the risk of erosion and sedimentation from the road system.

The overall impact from all cumulative sources would be moderate because of the large overall area of disturbance that would require soil protection in accordance with ongoing required reclamation programs and best management practices.

3.6.4.3.5.2 Trace Metals Deposition

The cumulative impacts of trace metal emission and dispersion from coal combustion sources are addressed in Section 3.1. Based on NGS air quality modeling in both near-field (50 km from the source) and far-field (300 km for the source), the majority of the deposition occurs within 20 km of NGS. Proposed KMC modeling indicates the majority of particulate deposition within the proposed KMC lease boundary. As a consequence there are limited or no trace metal emission interactions of NGS or proposed KMC with other regional coal-fired generation sources. As described in 3.1 Air Quality, NGS metals deposition represents a minor cumulative impact addition to other existing and foreseeable regional emissions sources. The Proposed Action contribution represents 1.7 to 2.2 percent of the estimated cumulative total mercury deposition rate (12.7 micrograms per square meter per year) (Section 3.1, Subsection 3.1.4.3). This cumulative total mercury deposition rate compares with a northern Arizona regional background deposition rate of 10 to 15 micrograms per square meter (Butler et al. 2007).NGS emissions represent 0.44 percent of total selenium deposition.

Interactions among regional coal generation sources with global scale sources result in cumulative biological impacts resulting from mercury deposition on soils, transport to waterbodies via sediment, and uptake by aquatic organisms. The impacts of mercury in fish tissue were estimated through air quality and sediment transport modeling studies conducted by Electric Power Research Institute (Electric Power Research Institute 2016). The results from the Electric Power Research Institute study were included in the ERAs conducted for aquatic life (Section 3.12), and special status fish species (Section 3.13) to estimate cumulative impacts (**Tables 3.13-11** and **3.13-12**).

3.6.4.4 Natural Gas Partial Federal Replacement Alternative

Under the Natural Gas Partial Federal Replacement (PFR) Alternative, a selected quantity of power between 100 megawatts (MW) and 250 MW would be contracted for under a long-term power purchase agreement from currently unidentified, existing natural gas generation sources, displacing an equivalent amount of power from the federal share of NGS generation. Because the facility is assumed to currently exist, prior disturbance impacts to Soil Resources are not evaluated. Below is a list of key assumptions about soil resources related to such an existing site.

- A combined-cycle natural gas power plant would typically be located on a site of approximately 100 acres. No additional surface disturbance would be required over time.
- Soil would be removed from the entire site, and would not be replaced and revegetated until after facility decommissioning.

- Natural gas combustion for power generation would not result in COPEC emissions and deposition that would overlap with the coal combustion emissions and deposition from NGS; therefore, there would be no deposition from natural gas combustion to soil in the Study Area. The description of emission calculations for the PFR are described in Chapter 2.0 and in Section 3.1, Air Quality.

Impact issues for the Natural Gas PFR Alternative are discussed across the range of NGS unit operations (3-Unit and 2-Unit) and associated alternative power reductions (100 MW and 250 MW) from the least NGS power reduction to the greatest. Reductions in NGS power generation would proportionally reduce the quantity of coal delivered from the Kayenta Mine.

3.6.4.4.1 Navajo Generating Station

3.6.4.4.1.1 Surface Disturbance/Erosion

The following operational factors would limit additional surface disturbance and soil stabilization efforts across the operating range of this, and other PFR alternatives:

- Current soil protection and erosion control measures and coal combustion residual inspection requirements would prevent soil erosion losses from the coal combustion residual landfill (**Appendix 1B**, page 52 and 94);
- The plant site is required to comply with stormwater permit requirements, which require retention of stormwater and associated sediment to prevent offsite soil erosion; and
- No new surface disturbance would be required to operate the BM&LP Railroad.

Salvaged surface materials would be sufficient to provide the necessary cover for all coal combustion residuals volumes generated across the entire operating range of this PFR alternative over the entire 200 acre active area of the coal combustion residuals landfill through 2044.

There would be insufficient coal combustion residuals landfill capacity to accommodate coal combustion residuals volumes through 2044 under the proposed 3-Unit Operation, requiring an expansion of the existing 200 acre active to accommodate an additional 3.7 million cubic yards (**Appendix 1B**, page 54). Neither the 3-Unit 100-MW or the 3-Unit 250-MW Natural Gas PFR operation would reduce coal combustion residual volumes sufficiently to avoid this expansion, thereby requiring new surface disturbance of approximately 20 percent or 40 acres. There would be sufficient combustion residuals landfill capacity to accommodate coal combustion residuals volumes through 2044 under the 2-Unit 100-MW and 250-MW PFR operations, and therefore no new soil disturbance would be required for a landfill expansion.

Demolition would result in removal of most NGS surface facilities, and reapplication of soil or suitable surface materials, and restoration with native vegetation (**Appendix 1B**, pages 99-106). This demolition process is common to all PFR alternatives.

The impacts of these activities across the operating range of the Natural Gas PFR Alternative would be moderate (same as Proposed Action) because the surface disturbance (approximately 3,700 acres) remaining after demolition would be subject to existing intensive surface management programs for both site erosion control and sedimentation, and for maintenance of short- and long-term stability of revegetated land surface.

3.6.4.4.1.2 Trace Metals Deposition from NGS Stack Emissions

Selenium, arsenic and mercury for the Natural Gas PFR Alternative NGS stack emissions would be reduced relative to the Proposed Action as presented in **Table 3.6-8** below:

Table 3.6-8 Comparison of Trace Metal Emissions Under the Proposed Action and Natural Gas PFR Alternative

Trace Metal	NGS Operation	Proposed Action Emissions (tpy)	Natural Gas PFR 100-MW Power Reduction Emissions (tpy / % change)[1]	Natural Gas PFR 2500-MW Power Reduction Emissions (tpy / % change)[1]
Selenium	3-Unt	2.237	2.127 / -5%	1.957 / -13%
Selenium	2-Unit	1.491	1.377 / -8%	1.208 / -19%
Mercury (total)	3-Unit	0.117	0.111 / -5%	0.102 / -13%
Mercury (total)	2-Unit	0.078	0.072 / -8%	0.063 / -19%
Arsenic	3-Unit	0.133	0.127 / -5%	0.117 / -12%
Arsenic	2-Unit	0.089	0.083 / -7%	0.073 / -18%

[1] Percent change represents the percentage reduction when compared to the Proposed Action.

The impacts of 5 to 19 percent lower trace metal deposition from this alternative (relative to the Proposed Action) would be minor because Proposed Action air quality modeling indicates that estimated deposition rates of selenium and mercury, combined with background soil concentrations, would not exceed ERA and HHRA soil screening levels that indicate a concentration level of concern. Background levels of arsenic are above the USEPA human health screening level, but in combination with very small project deposition under all alternatives, would not cause an unacceptable cancer risk as documented by the HHRA (Section 3.16, Public Health).

3.6.4.4.2 Proposed Kayenta Mine Complex

3.6.4.4.2.1 Surface Disturbance/Erosion

Under this PFR alternative, all mining through the life-of-mine would occur within the proposed KMC. Vegetation clearing, topsoil removal, topsoil salvage (direct haul and stockpiling), and mining methods would continue as described for the existing operations (PWCC 2012 et seq.). Additional topsoil stockpiles and additional drainage and sediment control structures would be added as mining progresses (PWCC 2012 et seq.). Disturbed areas would be restored to approximate landforms that existed prior to mining and would support vegetation similar to surrounding areas. As discussed previously, reclamation procedures will create a suitable 4-foot thick plant root zone over the entire reclaimed area and establish a diverse and permanent vegetation cover. All surface disturbance is subject to a soil stabilization and revegetation adequacy standard prior to release back to the surface owner, the Navajo Nation or Hopi Tribe.

Mining surface disturbance under this PFR alternative would be proportionally reduced as illustrated in **Table 3.0-7**. It is recognized that actual surface disturbance may not be directly proportional to coal mined because of differences in overburden and coal seam thickness across the coal resource areas.

The impacts of surface coal mining would be moderate because approximately 3,888 to 4,968 acres of new surface disturbance at risk for soil erosion are subject to existing intensive surface management programs for soil salvage, soil erosion control, sedimentation control, and revegetation (**Appendix 1D**). It is anticipated that approximately 9,000 to 10,000 acres of surface disturbance (coal mining areas and surface facilities) would remain for topsoil material application and revegetation by 2044.

peak mining years, and proximity of mining to downwind residential receptors. Because of the multiple variables included in modeling, the results cannot be proportionally scaled from one mining scenario to a lower one without further detailed modeling. To provide perspective, the deposition rates of trace metals were compared with the concentrations of arsenic, mercury, and selenium in Kayenta Mine soils and coal that were used for input to the ERA and HHRAs. Selenium and mercury background concentrations were below USEPA screening levels, and deposition rates of these metals would be less than 5 percent of the background levels.

Impacts from the deposition of trace metals contained in particulate matter originating from mining activities would be minor because estimated deposition rates of selenium and mercury, combined with background soil concentrations, would not exceed ERA and HHRA soil screening levels that indicate a concentration level of concern. Background levels of arsenic are above the USEPA human health screening level, but in combination with very small project deposition contribution under this PFR alternative, would not cause an unacceptable cancer risk as documented by the HHRA (Section 3.16, Public Health).

3.6.4.4.3 Transmission Systems and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

3.6.4.4.4 Project Impact Summary – All Project Components

The combined new soil disturbance at NGS and at proposed KMC under the Natural Gas PFR Alternative would range from a high of 5,265 to a low of 4,145 acres. This soil disturbance compares to a Proposed Action range of 5,527 acres to a low of 4,998 acres, or an overall 5 to 18 percent reduction in new land disturbance for this PFR alternative. Soil protection, and erosion and sediment control programs, and transmission line and communication site operation and maintenance activities would be the same as those for the Proposed Action. The impacts of new soil disturbance of this PFR would be moderate (same as the Proposed Action) because of the large scale (greater than 4000 acres) of new surface disturbance that would be stabilized by soil protection and revegetation measures mandated by federal and tribal agencies, and the requirement to apply soil materials and initiate revegetation after NGS decommissioning, and KMC closure in 2044 to approximately 9,000 to 10,000 acres.

Deposition of trace metals to soil from NGS and proposed KMC would be slightly less for this PFR than for the Proposed Action. The impacts of trace metals deposition would be minor (same as the Proposed Action) because the estimated selenium and mercury deposition concentrations, combined with background soil concentrations, would not exceed USEPA screening level standards for soil. Arsenic background concentrations are above the screening level at both NGS and proposed KMC; arsenic deposition from NGS and Kayenta Mine operations are very low. The combined concentrations from these sources would not cause an unacceptable cancer risk as documented by the HHRA (Section 3.16, Public Health).

3.6.4.4.5 Cumulative Impacts

3.6.4.4.5.1 Surface Disturbance/Erosion

The cumulative impacts of surface disturbance would be 1 percent less than those estimated for the Proposed Action. The surface disturbance contributed by this PFR alternative, past and present actions and foreseeable actions is estimated to be between 61,132 and 62,252 acres, of which approximately 3,624 acres at NGS, coal combustion residual landfill and railroad would require topsoil material reapplication and revegetation after demolition, and a range of 9,000 to 10,000 acres of mined land and surface facilities would remain to be reclaimed at the proposed KMC after 2044. An additional 4,201 acres of surface disturbance resulting from construction of foreseeable actions (transmission lines and water pipelines) would be topsoiled and reseeded in the near-term (assumed to be by 2025).

3.6.4.4.5.2 Trace Metal Deposition

The deposition to soils of selenium, arsenic, and mercury contained in stack emissions and particulate matter from both NGS and the proposed KMC under this PFR alternative (see Project Summary) would continue over a 24 year period primarily within a 20-km to 50-km radius of each facility and would not overlap with deposition from other existing coal combustion sources, or other foreseeable actions with the exception of mercury, which would add a small increment to existing regional and global sources. Based on emission rates for the Proposed Action, this alternative would reduce the NGS emissions contribution by 5 to 19 percent (**Table 3.6-8**).

3.6.4.5 Renewable Partial Federal Replacement Alternative

Under the Renewable PFR Alternative, a selected quantity of power between 100 MW and 250 MW would be contracted for under a long-term power purchase agreement from a currently unidentified, existing renewable energy power source, displacing an equivalent amount of power from the federal share of NGS generation. Because the facility is assumed to currently exist, prior disturbance impacts to Soil Resources are not evaluated. The following are key assumptions about soil resources related to such an existing site:

- A renewable energy generation facility (assumed to be photovoltaic) would typically be located on a site up to 3,000 acres. No additional surface disturbance would be required over time.
- Soil would be removed from the entire site, and would not be replaced and revegetated until after facility decommissioning.
- Photovoltaic panels that generate electrical energy would not cause deposition to soil of the trace metal associated with coal combustion under the Proposed Action. This difference in emissions is addressed in the Air Quality resource section.

Impact issues for this PFR alternative are discussed across the range of NGS unit operations (3-Unit and 2-Unit) and associated alternative power reductions (100 MW and 250 MW) from the least NGS power reduction to the greatest. Reductions in NGS power generation would proportionally reduce the quantity of coal delivered from the Kayenta Mine.

3.6.4.5.1 Navajo Generating Station

3.6.4.5.1.1 Surface Disturbance/Erosion

Operational factors would limit additional surface disturbance and soil stabilization efforts across the operating range of this, and other PFR alternatives.

- Current soil protection and erosion control measures and coal combustion residual inspection requirements would prevent soil erosion losses from the coal combustion residual landfill (**Appendix 1B**, pages 52 and 94).
- The plant site is required to comply with storm water permit requirements, which require retention of storm water and associated sediment to prevent offsite soil erosion.
- No new surface disturbance would be required to operate the BM&LP Railroad.

Salvaged surface materials would be sufficient to provide the necessary cover for all coal combustion residuals volumes generated across the entire operating range of this PFR alternative over the entire 200 acre active area of the coal combustion residuals landfill through 2044. The requirements for coal combustion residual landfill cover would be the same as those described for the Natural Gas PFR Alternative.

The impacts of these activities across the operating range of this PFR alternative would be moderate (same as Proposed Action) because the surface disturbance (approximately 3,624 acres) remaining after demolition would be subject to existing intensive surface management programs for both site erosion control and sedimentation, and for maintenance of short- and long-term stability of revegetated land surface.

3.6.4.5.1.2 Trace Metals Deposition from NGS Stack Emissions

Selenium, arsenic and mercury for PFR NGS stack emissions would be reduced relative to the Proposed Action as presented in **Table 3.6-9** below:

Table 3.6-9 Comparison of Trace Metal Emissions Under the Proposed Action and Renewable PFR Alternative

Trace Metals	NGS Operation	Proposed Action Emissions (tpy)	Renewable PFR 100-MW Power Reduction (tpy / % change)[1]	Renewable PFR 250-MW Power Reduction (tpy / % change)[1]
Selenium	3-Unt	2.237	2.174 / -3%	2.075 / -7%
Selenium	2-Unit	1.491	1.424 / -4%	1.325 / -11%
Mercury (total)	3-Unit	0.117	0.114 / -5%	0.108 / -8%
Mercury (total)	2-Unit	0.078	0.075 / -4%	0.069 / -12%
Arsenic	3-Unit	0.133	0.130 / -2%	0.124 / -7%
Arsenic	2-Unit	0.089	0.086 / -3%	0.080 / -10%

[1] Percent change represents the percentage reduction when compared to the Proposed Action.

The 3-Unit 100-MW and 250-MW PFR operations would result in emissions of approximately 2 to 8 percent less selenium, arsenic, and mercury than the 3-Unit Proposed Action; the 2-Unit 100-MW and 250-MW PFR operations would result in emissions of approximately 3 to 12 percent less for the same metals.

The impacts of 2 to 12 percent lower trace metal deposition from this alternative (relative to the Proposed Action) would be minor because Proposed Action air quality modeling indicates that estimated deposition rates of selenium and mercury, combined with background soil concentrations, would not exceed ERA and HHRA soil screening levels that indicate a concentration level of concern. Background levels of arsenic are above the USEPA human health screening level, but in combination with very small project deposition under all alternatives, would not cause an unacceptable cancer risk as documented by the HHRA (Section 3.16, Public Health).

3.6.4.5.2 Proposed Kayenta Mine Complex

3.6.4.5.2.1 Surface Disturbance/Erosion

Under this PFR alternative, all mining through the life-of-mine would occur within the proposed KMC. Vegetation clearing, topsoil removal, topsoil salvage (direct haul and stockpiling), and mining methods would continue as described for the existing operations (PWCC 2012 et seq.). Additional topsoil stockpiles and additional drainage and sediment control structures would be added as mining progresses (PWCC 2012 et seq.). Disturbed areas would be restored to approximate landforms that existed prior to mining and would support vegetation similar to surrounding areas. As discussed previously, reclamation procedures will create a suitable 4-foot thick plant root zone over the entire reclaimed area and establish a diverse and permanent vegetation cover. All surface disturbance is subject to a soil stabilization and revegetation adequacy standard prior to release back to the surface owner, the Navajo Nation or Hopi Tribe.

Mining surface disturbance under this PFR alternative would be proportionally reduced as illustrated in **Table 3.0-7**. It is recognized that actual surface disturbance may not be directly proportional to coal mined because of differences in overburden and coal seam thickness across the coal resource areas.

The impacts of surface coal mining would be moderate because approximately 5,072 to 4,267 acres of new surface disturbance at risk for soil erosion are subject to existing intensive surface management programs for soil salvage, soil erosion control, sedimentation control, and revegetation (**Appendix 1D**). It is estimated that 9,000 to 10,000 acres of surface disturbance (mine areas, surface facilities) would remain for reclamation in 2044.

3.6.4.5.2.2 Trace Metal Deposition from Suspended Particulates (Dust)

See the Natural Gas PFR Alternative for impact assumptions. Based on Proposed Action estimates, impacts from the deposition of trace metals contained in particulate matter originating from mining activities would be less than the Proposed Action, and minor because estimated deposition rates of selenium and mercury, combined with background soil concentrations, would not exceed ERA and HHRA soil screening levels that indicate a concentration level of concern. Background levels of arsenic are above the USEPA human health screening level, but in combination with very small project deposition contribution under this PFR alternative, would not cause an unacceptable cancer risk as documented by the HHRA (Section 3.16, Public Health).

3.6.4.5.3 Transmission Systems and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

3.6.4.5.4 Project Impact Summary – All Project Components

The combined new soil disturbance at NGS and at proposed KMC under the Renewable PFR would range from a high of 5,072 to a low of 4,267 acres. This soil disturbance compares to a Proposed Action range of 5,230 acres to a low of 4,741 acres, or an overall 3 to 10 percent reduction in new land disturbance for this PFR alternative. Soil protection, and erosion and sediment control programs, and transmission line and communication site operation and maintenance activities would be the same as those for the Proposed Action. The impacts of new soil disturbance of this PFR would be moderate (same as the Proposed Action) because of the large scale (greater than 4,000 acres) of new surface disturbance that would be stabilized by soil protection and revegetation measures mandated by federal and tribal agencies, and the requirement to apply soil materials and initiate revegetation after NGS decommissioning, and KMC closure in 2044 to approximately 9,000 to 10,000 acres.

Deposition of trace metals to soil from NGS and proposed KMC would be slightly less (**Table 3.6-10**) for this PFR than for the Proposed Action. The impacts of trace metals deposition would be minor (same as the Proposed Action) because deposition concentrations would not exceed USEPA protective screening criteria for soils.

3.6.4.5.5 Cumulative Impacts

3.6.4.5.5.1 Surface Disturbance/Erosion

The cumulative impacts of surface disturbance would be less than one percent of those estimated for the Proposed Action. The scale and location of surface disturbance would be nearly the same as that described for the Natural Gas PFR Alternative.

3.6.4.5.5.2 Trace Metal Deposition

The deposition to soils of selenium, arsenic, and mercury contained in stack emissions and particulate matter from both NGS and the Kayenta Mine under this PFR alternative (see Project Summary) would continue over a 24-year period primarily within a 20-km to 50-km radius of each facility and would not overlap with deposition from other existing coal combustion sources, or other foreseeable actions with the exception of mercury, which would add a very small increment to existing regional and global sources. Based on emission rates for the Proposed Action, this alternative would reduce the NGS emissions contribution by 2 to 12 percent (**Table 3.6-9**).

3.6.4.6 Tribal Partial Federal Replacement Alternative

Under the Tribal PFR Alternative, between 100 MW and 250 MW of power generation from the NGS would be replaced by power supplied by a new photovoltaic generation facility on tribal land, displacing an equivalent amount of power from the federal share of NGS generation. The construction of a new photovoltaic generation site on tribal land would result in between 1,200 and 3,000 acres of new surface disturbance. The Tribal PFR facility would be analyzed in a separate NEPA process once a facility location is identified. Key assumptions about soil resources related to such a site are listed below:

- A renewable energy generation facility (assumed to be photovoltaic) would typically be located on a site of approximately of 1,200 to 3,000 acres to meet the requirement to provide 100 MW to 250 MW. This estimate includes an interconnecting transmission line of 5 miles, with a 100-foot ROW.
- The site would be located on an upland, level site. Intermittent or perennial drainage channels would be avoided during site selection. The possible major soil units where the project would be located include Land Resource Area 35 (Colorado Plateau), and Land Resource Area 40 (Sonoran Basin and Range). An overview of these Land Resource Areas is provided in Section 3.6.3. In general, the soils are expected to be generally shallow, with very limited horizon development because of the arid climate. Soil would be removed from the entire site, and would not be replaced and revegetated until after facility decommissioning.
- Natural gas firming power would not result in trace metal emissions deposition that would overlap with the associated with coal combustion emissions and deposition from NGS under the Proposed Action; therefore, there would be no deposition from the natural gas combustion to soil in the Study Area. The emissions caused from construction of the solar facility (fugitive dust and vehicle exhaust) could be located in the NGS and KMC study areas but would be very localized and temporary, and therefore, considered to have no effect on soil resources and not carried forward in the analysis. This description of emission calculations for the PFR are described in Chapter 2.0 and in Section 3.1, Air Quality.

Impact issues for this PFR alternative are discussed across the range of NGS unit operations (3-Unit and 2-Unit) and associated alternative power reductions (100 MW and 250 MW) from the least NGS power reduction to the greatest. Reductions in NGS power generation would proportionally reduce the quantity of coal delivered from the Kayenta Mine.

3.6.4.6.1 Navajo Generating Station

3.6.4.6.1.1 Surface Disturbance/Erosion

Surface disturbance and soil stabilization management practices would be the same as those described for the Natural Gas PFR Alternative.

Salvaged surface materials would be sufficient to provide the necessary cover for all coal combustion residuals volumes generated across the entire operating range of this PFR alternative over the entire 200 acre active area of the coal combustion residuals landfill through 2044. The requirements for coal combustion residual landfill cover would be the same as those described for the Natural Gas PFR Alternative.

The impacts of these activities across the operating range of this PFR alternative would be moderate (same as Proposed Action) because the surface disturbance (approximately 3,624 acres) remaining after demolition would be subject to existing intensive surface management programs for both site erosion control and sedimentation, and for maintenance of short- and long-term stability of revegetated land surface.

3.6.4.6.1.2 Trace Metals Deposition from NGS Stack Emissions

Selenium, arsenic and mercury for PFR NGS stack emissions would be reduced relative to the Proposed Action as presented in **Table 3.6-10** below:

Table 3.6-10 Comparison of Trace Metal Emissions Under the Proposed Action and Tribal PFR Alternative

Trace Metal	NGS Operation	Proposed Action Emissions (tpy)	Tribal PFR 100-MW Power Reduction Emissions (tpy / % change)[1]	Tribal PFR 250-MW Power Reduction Emissions (tpy / % change)[1]
Selenium	3-Unt	2.237	2.174 / -3%	2.123 / -5%
Selenium	2-Unit	1.491	1.424 / -4%	1.325 / -11%
Mercury (total)	3-Unit	0.117	0.114 / -3%	0.111 / -5%
Mercury (total)	2-Unit	0.078	0.076 / -3%	0.072 / -8%
Arsenic	3-Unit	0.133	0.130 / -2%	0.127 / -5%
Arsenic	2-Unit	0.089	0.087 / -2%	0.083 / -7%

[1] Percent change represents the percentage reduction when compared to the Proposed Action.

The 3-Unit 100-MW and 250-MW PFR operations would result in emissions of approximately 2 to 5 percent less selenium, arsenic, and mercury than the 3-Unit Proposed Action; the 2-Unit 100-MW and 250-MW PFR operations would result in emissions of approximately 2 to 11 percent less for the same metals.

The impacts of 2 to 11 percent lower trace metal deposition from this alternative (relative to the Proposed Action) would be minor because Proposed Action air quality modeling indicates that estimated deposition rates of selenium and mercury, combined with background soil concentrations, would not exceed ERA and HHRA soil screening levels that indicate a concentration level of concern. Background levels of arsenic are above the USEPA human health screening level, but in combination with very small project deposition under all alternatives, would not cause an unacceptable cancer risk as documented by the HHRA (Section 3.16, Public Health).

3.6.4.6.2 Proposed Kayenta Mine Complex

3.6.4.6.2.1 Surface Disturbance/Erosion

In accordance with the Kayenta Mine life-of-mine plan, continued coal surface mining requires that soil materials be salvaged and protected by excavating soils to an approved depth, and then stockpiled. Based on chemical and physical characteristics, stockpiled soil materials are mixed with suitable overburden to achieve a growth medium suitable for revegetation. Erosion control and sedimentation structures are placed downslope from disturbed areas, limiting the movement of soil and sediment away from active mining areas (**Appendix 1D**). Under this PFR Alternative, all mining through the life-of-mine would occur within the proposed KMC. Vegetation clearing, topsoil removal, topsoil salvage (direct haul and stockpiling), and mining methods would continue as described for the existing operations (PWCC 2012 et seq.). Additional topsoil stockpiles and additional drainage and sediment control structures would be added as mining progresses (PWCC 2012 et seq.). Disturbed areas would be restored to approximate landforms that existed prior to mining and would support vegetation similar to surrounding areas. As discussed previously, reclamation procedures will create a suitable 4-foot thick plant root zone over the entire reclaimed area and establish a diverse and permanent vegetation cover. All surface disturbance is subject to a soil stabilization and revegetation adequacy standard prior to release back to the surface owner, the Navajo Nation or Hopi Tribe.

Mining surface disturbance under this PFR alternative would be proportionally reduced as illustrated in **Table 3.0-7**. It is recognized that actual surface disturbance may not be directly proportional to coal mined because of differences in overburden and coal seam thickness across the coal resource areas.

The impacts of surface coal mining would be moderate because approximately 5,124 to 4,409 acres of new surface disturbance at risk for soil erosion are subject to existing intensive surface management programs for soil salvage, soil erosion control, sedimentation control, and revegetation (**Appendix 1D**). It is estimated that 9,000 to 10,000 acres of surface disturbance (mine areas, surface facilities) would remain for reclamation in 2044.

3.6.4.6.2.2 Trace Metal Deposition from Suspended Particulates (Dust)

See the Natural Gas PFR Alternative for impact assumptions. Based on Proposed Action estimates, impacts from the deposition of trace metals contained in particulate matter originating from mining activities would be less than the Proposed Action, and minor because estimated deposition rates of selenium and mercury, combined with background soil concentrations, would not exceed ERA and HHRA soil screening levels that indicate a concentration level of concern. Background levels of arsenic are above the USEPA human health screening level, but in combination with very small project deposition contribution under this PFR alternative, would not cause an unacceptable cancer risk as documented by the HHRA (Section 3.16, Public Health).

3.6.4.6.3 Transmission Systems and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

3.6.4.6.4 Project Impact Summary – All Project Components

The combined new soil disturbance at NGS and at proposed KMC under the Renewable PFR would range from a high of 5,124 to a low of 4,409 acres. This soil disturbance compares to a Proposed Action range of 5,230 acres to a low of 4,741 acres, or an overall 2 to 7 percent reduction in new land disturbance for this PFR alternative. Soil protection, and erosion and sediment control programs, and transmission line and communication site operation and maintenance activities would be the same as those for the Proposed Action. The impacts of new soil disturbance of this PFR would be moderate (same as the Proposed Action) because of the large scale (greater than 4,000 acres) of new surface disturbance that would be stabilized by soil protection and revegetation measures mandated by federal and tribal agencies. In addition, from 1,200 to 3,000 additional acres would be disturbed to construct a new photovoltaic generation facility and interconnecting transmission line. Decommissioning of these same areas would be required at the end of the photovoltaic facility life. It is assumed that standard soil salvage and protection measures would be implemented in compliance with National Environmental Policy Act Record of Decision conditions, and lease agreements.

Deposition of trace metals to soil from NGS and proposed KMC would be slightly less for this PFR than for the Proposed Action. The impacts of trace metals deposition would be minor (same as the Proposed Action) because deposition concentrations would not exceed USEPA protective screening criteria for soils.

3.6.4.6.5 Cumulative Impacts

3.6.4.6.5.1 Surface Disturbance/Erosion

The maximum cumulative impacts of surface disturbance (including a new photovoltaic facility ranging in size from 1,200 to 3,000 acres) would be approximately 5 percent more than those estimated for the Proposed Action (3-Unit Operation). Approximately 4,201 acres would result from construction of new transmission lines and water pipelines in the WTS corridor in Arizona, Utah, and Nevada. All identified new soil disturbance would be subject to soil stripping, salvage, and reapplication measures administered by a responsible federal agency.

3.6.4.6.5.2 Trace Metal Deposition

The deposition to soils of selenium, arsenic, and mercury contained in stack emissions and particulate matter from both NGS and the Kayenta Mine under this PFR alternative (see Project Summary) would continue over a 24 year period primarily within a 20 to 50 km radius of each facility and would not overlap with deposition from other existing coal combustion sources, or other foreseeable actions with the exception of mercury, which would add a small increment to existing regional and global sources. Based on emission rates for the Proposed Action, this alternative would reduce the NGS emissions contribution by 3 to 11 percent (**Table 3.6-10**).

3.6.4.7 No Action

3.6.4.7.1 Navajo Generating Station

3.6.4.7.1.1 Surface Disturbance/Erosion

If continued operation of the NGS and the BM&LP Railroad is not approved, the power plant, associated facilities, and the BM&LP Railroad would be decommissioned as described above in the Proposed Action. Management of soils would be the same as described for the Proposed Action. Approximately 3,624 acres would require soil material application and reseeding. This number of acres assumes that 100 acres of facilities would be turned over to the Navajo Nation, and would not be decommissioned.

3.6.4.7.1.2 Trace Metal Deposition from NGS Stack Emissions

Trace metal deposition from NGS stacks would cease after 2018. Soil surface concentrations of selenium, mercury, and arsenic would similar to the concentrations measured from baseline soil sampling programs completed in 2014 (**Table 3.6-2**). Ecological and HHRAs were conducted for near-field baseline (No Action) conditions, based on this recent soil sampling. Refined HQs for all of the terrestrial wildlife and vegetation receptors were less than 1 for all COPECs for baseline conditions within the NGS Near-field study area, indicating that risks to terrestrial communities from baseline conditions (including exposure to soils) are negligible (Section 3.10). The baseline HHRA found that all cancer and non-cancer risks (including lead) were in the acceptable range in relation to USEPA and Center for Disease Control criteria. Fugitive dust generation would occur during decommissioning activities, which would be completed by 2020.

3.6.4.7.2 Proposed Kayenta Mine Complex

3.6.4.7.2.1 Surface Disturbance/Erosion

If the continued operation at the proposed KMC is not approved, all disturbed lands that exist in 2019 would be regraded, and a suitable mixture of soil and overburden would be applied in accordance with existing programs overseen by OSMRE. Approximately 5,230 acres would be disturbed if mining ceased in 2019 than under the Proposed Action.

3.6.4.7.2.2 Trace Metal Deposition from Suspended Particulates (Dust)

Refined HQs for all of the terrestrial wildlife and vegetation receptors were less than 1 for all COPECs for baseline (No Action) conditions within the KMC study area, indicating that risks to terrestrial communities from baseline conditions (including exposure to soils) are negligible (Section 3.8, Vegetation, Section 3.10, Terrestrial Wildlife).

Based on the cancer risk estimates, non-cancer and target organ analysis hazard indexes, and the separate evaluation for blood lead in children, there were no unacceptable human health risks identified for the baseline (No Action) risk case. Because all baseline human health risks were considered acceptable, negligible impact on human health was identified in the vicinity of the proposed KMC (Section 3.16, Public Health).

3.6.4.7.3 Transmission Systems and Communication Sites

The NGS transmission system is an established part of the western U.S. transmission grid and supports reliability and delivery of power throughout the region, well beyond the power generated by the NGS. Therefore, under the No Action Alternative it is likely that that one, several, or all of the land owners/managers of the transmission line rights-of-way and communication site leases would renew some portion of the facilities to keep the power grid performing as expected.

In the event it is determined that some or all of the transmission systems and communication site ROWs are not renewed, a lengthy study and permitting process would need to occur before any decommissioning is initiated due to the essential and integral nature of these facilities with the western electric grid. Based on the assumptions presented in Section 2.3.3, an estimated 4,826 acres could be temporarily disturbed if the entirety of the transmission systems and communication sites were decommissioned and removed.

Only after it is determined which facilities would be decommissioned, replaced and/or would remain can the specific areas that would be disturbed by decommissioning activities be identified. Subsequent NEPA compliance would be initiated once these plans are completed.

3.6.4.7.4 No Action Impact Summary – All Project Components

The decommissioning activities at NGs and the reclamation at KMC would be the same as those described for the Proposed Action except that these activities would be initiated starting in 2018. Total project reclamation requirements are estimated to be 9,272 acres (**Table 3.0-2**). NGS decommissioning would be completed in 2020; reclamation at KMC would occur over a 5 to 10 year time frame (and possibly longer depending on revegetation success).

As described for the individual project components, near-field NGS stack emissions and KMC fugitive dust emissions from mining would cease in 2018. Trace metal concentrations in soils are expected to remain similar to the concentrations of these components measured from field sampling in 2014. Local fugitive dust emissions and deposition would continue during decommissioning activities that are expected to conclude in 2020 at NGS, and over a 10-year period or longer at KMC. The baseline (No Action) risks to ecological and human health are expected to remain negligible over time because there would be a net reduction in pollutant emissions when both sources cease operations.

3.6.5 References

Butler, T., G. Likens, M. Cohen, and F. Vermeylen. 2007. Mercury in the Environment and Patterns of Mercury Deposition from the NADP/MDN Mercury Deposition Network. Final Report. 87 pages.

Electric Power Research Institute (EPRI). 2016. A Case Study Assessment of Trace Metal Atmospheric Emissions and their Aquatic Impacts in the San Juan River Basin. Phase 2: Navajo Generating Station. 3002006244. R. Goldstein and L. Levin. Final Report. April 2016.

Flatirons Toxicology, Inc. 2015. Kayenta Mine Complex Human Health Risk Assessment. Revision E. December. Prepared for Peabody Western Coal Company.

Lehn, R. 2016. Personal communication from Randy Lehn, PWCC to Anne Baldridge, AECOM. E-mail exchange concerning assumptions for the acreage of KMC surface disturbance and the acreage remaining to be reclaimed in 2019 and 2044. May 4, 2016.

McVehil-Mommett Associates, Inc. (MMA). 2016. Kayenta Mine Complex Air Quality Modeling Analysis Final Report. MMA Project Number 2574-13. January 2016.

Office of Surface Mining Reclamation and Enforcement (OSMRE). 2011. Environmental Assessment: Kayenta Mine Permit (AZ-0001D) Renewal (Navajo County, Arizona). U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement (Western Region). August 2011. 185 pp + appendices.

Office of Surface Mining Reclamation and Enforcement (OSMRE). 2008. Black Mesa Project Environmental Impact Statement. DOI FES 08-49, OSM-EIS-33. November 2008.

Peabody Western Coal Company (PWCC). 2012, et seq. Kayenta Complex Permanent Program Permit AZ-0001E Life-of-Mine Plan Revision. Submitted to OSMRE May 1, 2012. Last updated March 27, 2015.

Pranger, H. S., II. 2000. Geomorphic Development of a Reconstructed Subalpine Stream Channel. 2000 Billings Land Reclamation Symposium. March 20-24, 2000 – Sheraton Billings Hotel. Billings, Montana.

Ramboll Environ. 2016a. DRAFT FINAL NGS Near-Field Ecological Risk Assessment Environmental Impact Statement Final Report for the Navajo Generating Station. Version 2. March 2016.

Ramboll Environ. 2016b. DRAFT FINAL NGS San Juan River Ecological Risk Assessment Environmental Impact Statement Summary Report for the Navajo Generating Station. April 2016.

Ramboll Environ. 2016c. DRAFT FINAL NGS Gap Region Ecological Risk Assessment Environmental Impact Statement Final Report for the Navajo Generating Station. March 2016.

Ramboll Environ. 2016d. DRAFT FINAL Ecological Risk Assessment Environmental Impact Statement Final Report for the Kayenta Mine Complex. April 2016.

Ramboll Environ. 2016e. DRAFT FINAL Human Health Risk Assessment, the Navajo Generating Station. January 2015.

Ramboll Environ. 2016f. FINAL NGS Sampling Investigation Report, Salt River Project – Navajo Generating Station. Revision 1. December 2015.

Ramboll Environ. 2016g. FINAL KMC Sampling Investigation Report, Salt River Project – Kayenta Mine Complex. April 2016.

Ramboll Environ. 2016h. Near-field Air Dispersion and Deposition Modeling Report for Navajo Generating Station, National Environmental Policy Act Environmental Impact Statement and Endangered Species Act Compliance. Final Report. April 2016.

Sheoran, V., A. S. Sheoran, and P. Poonia. 2010. Soil Reclamation of Abandoned Mine Land by Revegetation: A Review. International Journal of Soil, Sediment and Water 3(2):Article 13. Internet website: http://scholarworks.umass.edu/intljssw/vol3/iss2/13 Accessed July 19, 2016.

Smith, D. B., W. F. Cannon, L. G. Woodruff, F. Solano, J. E. Kilburn, and D. L. Fey. 2013 Geochemical and Mineralogical Data for Soils of the Conterminous United States: U.S. Geological Survey Data Series 801, 19 p. Internet website: http://pubs.usgs.gov/ds/801/. Accessed May 20, 2016.

Stahl, P. D., B. L. Perryman, S. Sharmasarkar, and L. C. Munn, 2000. Topsoil Stockpiling vs. Exposure to Traffic: A Case Study on an In-Situ Uranium Wellfield. 2000 Billings Land Reclamation Symposium. March 20-24, 2000 – Sheraton Billings Hotel. Billings, Montana.

Surface Mining Control and Reclamation Act of 1977 (SMCRA). Public Law 95-87. Internet website: http://www.osmre.gov/lrg/docs/SMCRA.pdf Accessed July 19, 2016.

U.S. Department of Agriculture (USDA)-Natural Resources Conservation Service (NRCS). 2015. SSURGO/STATSGO.

U.S. Department of Agriculture (USDA)-Natural Resources Conservation Service (NRCS). 2006. Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. Internet website: http://soils.usda.gov/MLRAExplorer. Accessed February 9, 2016.

Wick, A. F., P. D. Stahl, L. J. Ingram, and L. Vicklund. 2008. Soil Aggregate and Aggregate Associated Carbon Recovery in Short-term Stockpiles. Paper presented at the 2008 National Meeting of the American Society of Mining and Reclamation, Richmond, Virginia. New Opportunities to Apply Our Science June 14-19, 2008. R. I. Barnhisel (editor). Published by ASMR, Lexington, Kentucky. Pages 1389-1412.

Winges, K. and R. Steffel. 2016. Coal Dust from Rail Transport. Prepared for Navajo Generating Station Application Studies. Salt River Project Agricultural Improvement and Power District. Black Mesa and Lake Powell Railroad. January 2016.

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Section 3.7

Water Resources

Acronyms and Abbreviations

µg/L	micrograms per liter
1969 Lease	Navajo Project Indenture of Lease
amsl	above mean sea level
BART	Best Available Retrofit Technology
bgs	below ground surface
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BM&LP Railroad	Black Mesa & Lake Powell Railroad
BO	Biological Opinion
CAP	Central Arizona Project
CCR	Coal Combustion Residual
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
CO_2	carbon dioxide
Co-tenants	Salt River Project, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company
Development Fund	Lower Colorado River Basin Development Fund
EIS	Environmental Impact Statement
ERA	Ecological Risk Assessment
ESA	Endangered Species Act of 1973
gpd	gallons per day
gpm	gallons per minute
HHRA	Human Health Risk Assessment
km	kilometer
KMC	Kayenta Mine Complex
kV	kilovolt
kW	kilowatt
mg/L	milligrams per liter
MW	megawatt
NAV	N-Aquifer well (PWCC)
NEPA	National Environmental Policy Act of 1969, as amended
NGS	Navajo Generating Station
NGS Participants	U.S. (Reclamation), Salt River Project, Arizona Public Service Company, NV Energy, and Tucson Electric Power Company
NHPA	National Historic Preservation Act
NPDES	National Pollutant Discharge Elimination System
NNEPA	Navajo Nation Environmental Protection Agency
NO_2	nitrogen dioxide

NO_X	nitrogen oxide
NSPG	Native Spring (PWCC)
OSMRE	Office of Surface Mining Reclamation and Enforcement
PAP	Permit Application Package (PWCC and OSMRE)
PFR	Partial Federal Replacement
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter of 10 microns or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 microns or less
PWCC	Peabody Western Coal Company
Reclamation	U.S. Bureau of Reclamation
ROW	Right-of-way
SDWA	Safe Drinking Water Act
SO_2	sulfur dioxide
SPCC Plan	Spill Prevention, Control, and Countermeasure Plan
SRP	Salt River Project Agricultural Improvement and Power District
STS	Southern Transmission System
TDS	Total Dissolved Solids
tpy	tons per year
TSS	Total Suspended Solids
U.S.	United States
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WTS	Western Transmission System

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3.7 Water Resources

This resource section is organized similarly to that for other resources, wherein the study area definitions and a regulatory framework are presented first. Following these is a general discussion of the regional hydrologic setting. This is followed by detailed Affected Environment descriptions for the Navajo Generating Station (NGS) and then the proposed Kayenta Mine Complex (KMC), in sequence. These subsections discuss water resources characteristics, both recent and historical, for the immediate project area at each facility. Water resources in the broader, regional cumulative study areas are largely discussed in a separate appendix (**Appendix WR-8**) incorporated as part of the Environmental Impact Statement (EIS). The Affected Environment section is followed by the assessment of Environmental Consequences, with discussion of major project components aligned in a similar order. Additional reference information, more detailed data, and discussion are presented in water resources appendices. These are part of the EIS and can be further examined by more technically oriented readers.

3.7.1 Regulatory Framework

Both NGS and the Kayenta Mine have been constructed, operated, and maintained to address a number of environmental programs administered by several regulatory agencies. Project component designs, inspection and monitoring, maintenance, and reporting are major elements of regulatory permit approvals. These are reflected in the facilities and activities at both the NGS, the Kayenta Mine, and the transmission system, which are described further in Chapter 1.0.

3.7.1.1 Navajo Generating Station

The Salt River Project Agricultural Improvement and Power District (SRP) Operation and Maintenance Plan (**Appendix 1B**) and its appendices describe the components and environmental programs at NGS. **Table 3.7-1** summarizes the permits and programs involving water and its management at NGS. The SRP also has conducted groundwater monitoring at the plant site since plant operations began in the mid-1970's, and is revising its Groundwater Protection Plan in response to ongoing U.S. Environmental Protection Agency (USEPA) regulatory revisions including the coal combustion residual (CCR) rule. Additional regulatory programs for other materials or resources, such as wastes or air quality, are discussed in Chapter 1.0 and corresponding EIS sections.

As noted in **Table 3.7-1**, an industrial operating National Pollutant Discharge Elimination System (NPDES) permit is not required at NGS. With respect to industrial waste water, the plant operates as a zero-liquid-discharge facility. This is due to the water recycling design and operation of the plant, which include the use of brine concentrators and a crystallizer, as well as lined and monitored storage and evaporation ponds, to eliminate off-site industrial discharges. This is described further in the Operation and Maintenance Plan (**Appendix 1B**).

Storage tanks with up to 5 million gallons capacity exist at NGS for diesel fuel, and a number of other fuel or lubricant storage tanks with capacities ranging from 100 to 16,000 gallons also are present on-site. As implemented at NGS, the USEPA-approved Spill Prevention, Control, and Countermeasure (SPCC) Plan addresses containment requirements and the activities that would take place if a spill of a petroleum product occurred. Spill prevention and response for other materials are addressed in the storm water permit and program.

Table 3.7-1 Regulatory Programs for NGS Water Management

Permit or Requirement	Constituent Regulated	Agency / Jurisdiction
Safe Drinking Water Act	On-site potable water	No permit is required, but water operator(s) for the NGS potable water system are certified at the appropriate regulatory level.
National Pollution Discharge Elimination System Permit	Industrial waste water discharges	Exempt; no permit is required because there are no discharges
Multi-Sector General and Construction Permit for Stormwater Discharges	Stormwater discharges	USEPA
Clean Water Act Section 316(b) Cooling Water Intake Structure – Final Rule	Impingement and entrainment of aquatic life	USEPA
SPCC Plan	Possible oil spills from storage tanks	USEPA

3.7.1.2 Proposed Kayenta Mine Complex

Similar to NGS, water management at the Kayenta Mine is conducted in response to regulatory requirements and operational requirements such as dust suppression. The SPCC Plan at the Kayenta Mine addresses petroleum product containment requirements and response actions if a spill occurs. Relevant materials stored at the Kayenta Mine include gasoline, diesel and aviation fuels, lubricants and degreasers, transformers, and others. All tanks and containers have secondary containment such as lined spill boxes, berms, or double-wall designs or are operated within the facility drainage control system (which is secondary containment in accordance with SPCC requirements). No discharges to streams of these SPCC-related materials have occurred in the Kayenta Mine history (Peabody Western Coal Company [PWCC] 2012 et seq.). Other programs involving surface water and groundwater quantity, quality, and their protection at the Kayenta Mine are listed in **Table 3.7-2**.

Table 3.7-2 Regulatory Programs for Kayenta Mine Water Management

Permit or Requirement	Constituent Regulated	Agency / Jurisdiction
Surface Mining Control and Reclamation Act permit to conduct surface coal mining and reclamation operations	Surface water, groundwater, water supply, wastewater, monitoring and reclamation	Office of Surface Mining Reclamation and Enforcement (OSMRE) Indian Lands Program
Mine Safety and Health Administration design and safety standards for water, sediment, or slurry impoundments and impounding structures	Dams meeting regulated embankment sizes and/or storage volume capacities	Mine Safety and Health Administration
Navajo Nation Safe Drinking Water Act	On-site potable water	Navajo Nation Environmental Protection Agency (NNEPA)
National Pollution Discharge Elimination System Permit	Releases to receiving waters from sediment ponds, impoundments	USEPA in cooperation with OSMRE and the NNEPA Water Quality Program

Table 3.7-2 Regulatory Programs for Kayenta Mine Water Management

Permit or Requirement	Constituent Regulated	Agency / Jurisdiction
Multi-sector General Permit AZR051000	Storm water	USEPA Region 9
Nationwide Permit 21	Dredge and fill in Waters of the U.S.	U.S. Army Corps of Engineers
Public Water System Permit	Potable water	NNEPA – Public Water Systems Supervision Program
Clean Water Act Section 401 Water Quality Certification	Releases to receiving waters from sediment ponds, impoundments, reclaimed drainages	NNEPA – Water Quality Program, Hopi Tribe Department of Natural Resources – Water Resources Program
Wastewater Treatment System Permits	Sanitation facilities (domestic wastewater)	NNEPA
Water Well Drilling & Completion, Use, Abandonment	Groundwater	Water Code Administration (within the Navajo Nation Department of Water Resources), and the Hopi Tribe Department of Natural Resources – Water Resources Program
SPCC Plan	Possible spills of petroleum products from storage tanks	USEPA

Water supply and sanitary facilities at the Kayenta Mine are constructed, operated, and maintained in accordance with the Safe Drinking Water Act and related system permits through the NNEPA. In addition to industrial uses of the wellfield, some of the supply wells (NAV series of N-Aquifer water wells) have been operated as part of the potable water system. Currently NAV wells 2, 6, and 8 are used for potable supply; other configurations have been used historically. The N-Aquifer wells also are used for dust suppression, fire suppression, and livestock drinking water. Coal lease agreements require equal payments to the Navajo Nation and Hopi Tribe for withdrawal and use of N-Aquifer water. In addition, PWCC N-Aquifer withdrawals provide public potable water supplies made available to local residents from certain NAV wells at two public water stands. NAV well construction and any subsequent actions such as capping and abandonment are regulated by tribal authorities as noted above (**Table 3.7-2**).

Surface Mining Control and Reclamation Act regulations and the approved Kayenta Mine permit form a major basis for water management and monitoring at the Kayenta Mine. The regulatory program guides baseline water resources characterization; assessment of potential impacts; and the design, construction, and operation of water controls to address protection of the hydrologic balance. Mine and facility drainage is necessary for operations. The control features involved are discussed in Chapter 1.0. Ditches, diversions, and sediment ponds are configured, inspected, and maintained at the Kayenta Mine according to (or in excess of) the Surface Mining Control and Reclamation Act permit requirements, and Mine Safety and Health Administration requirements as applicable. Surface water and groundwater monitoring are conducted throughout the lease areas, and detailed reports are submitted annually as part of permit compliance. Overburden/interburden characterization and handling, regrading to approximate original contours, and restoration of stable drainages and landforms are part of reclamation activities performed in accordance with the Surface Mining Control and Reclamation Act permit. These reclamation activities help control runoff, runoff water quality, groundwater quality, and seepage on reclaimed lands. Other reclamation protections include bonding and release requirements.

In concert with Surface Mining Control and Reclamation Act permit provisions, the NPDES System permit and the Clean Water Act Section 401 Water Quality certifications guide activities that control the amount and quality of stormwater runoff, industrial facility runoff, and sediment discharged from the Kayenta Mine. The purpose of these regulatory programs is to maintain or improve water quality, with the overall goal of sustaining (or achieving) designated surface water uses. For the Kayenta Mine, the USEPA Region IX is the permitting authority for wastewater discharge under the NPDES; OSMRE is the permitting authority for the mining permit pursuant to Surface Mining Control and Reclamation Act (OSMRE 2003). Wastewater and storm water management requirements overlap considerably between the Surface Mining Control and Reclamation Act and NPDES programs. Releases to receiving waters must comply with permit requirements, and monitoring is required and conducted to ascertain water quality. Receiving waters in the Kayenta Mine permit area include Coal Mine Wash, Moenkopi Wash, Dinnebito Wash, Yellow Water Canyon Wash, and their applicable tributaries (**Figure 3.7-3**).

The NPDES program and its related permits are administered by the federal USEPA. USEPA stormwater permit AZR05F121 is issued under the 2015 Multi-Sector General Permit for Stormwater (USEPA 2015, 2010). The storm water permit applies to storm water discharges from outfalls on Shonto Wash, Laguna Creek, Coal Mine Wash, Yellow Water Canyon Wash, and Moenkopi Wash. Storm water runoff from limited areas including haul road crossings and access roads along the coal conveyor beltline is treated by structural or non-structural best management practices in accordance with the Storm Water Pollution Prevention Plan. Additional management practices related to materials storage, employee training and good housekeeping, inspections and maintenance, and monitoring and reporting also are implemented.

Industrial discharges to surface waters are reported to USEPA under point source permit NN0022179 for treated wastewater. The wastewater permit is for alkaline mine drainage, drainage from coal preparation areas, and western alkaline reclamation according to USEPA categories. For reclaimed mine areas that qualify under the western alkaline reclamation category, the wastewater permit relies on the use of Best Management Practices identified and implemented through a Sediment Control Plan. The plan identifies Best Management Practices and design specifications, construction specifications, maintenance schedules, and criteria for inspection, as well as the expected performance and longevity of the Best Management Practices (OSMRE 2003). USEPA, OSMRE, the Tribes, and the Bureau of Indian Affairs conduct concurrent reviews of the permit during the application process. OSMRE receives reports cooperatively through the Surface Mining Control and Reclamation Act monitoring program requirements and its Memorandum of Understanding with USEPA. Under the NPDES program, USEPA, OSMRE, and the Tribes are to coordinate closely on inspections of the sediment controls included in the NPDES and Surface Mining Control and Reclamation Act permits (OSMRE 2003).

3.7.1.3 Tribal Water Quality Standards

Tribal water quality standards, based on designated uses, narrative and numeric criteria, and anti-degradation policies, form the basis for more specific receiving water standards and related water management at NGS and Kayenta Mine. NNEPA administers the water quality standards for surface water and groundwater on Navajo lands. The Hopi Tribe Water Resources Program administers the water quality standards for surface water and groundwater on Hopi lands. Criteria apply generally or more specifically, based on uses of designated surface waterbodies and their tributaries. Common designated uses of surface waters on tribal lands include livestock watering, human full body and/or partial body contact, domestic water supply, and aquatic and wildlife habitat. Surface water and groundwater supplies for domestic water purposes are subject to Safe Drinking Water regulations and criteria. Both tribal groundwater programs are based on the Safe Drinking Water Act. Designated uses and related criteria are described in more detail in **Appendix WR-1, Tables WR-1.1** through **WR-1.4**.

In addition to domestic wastewater regulations, both the Hopi Tribe and the Navajo Nation have developed wellhead protection programs to address potential groundwater contamination sources at or near water supply wells (Hopi Tribe Water Resources Program 1996; NNEPA 2010). These programs have been developed to protect groundwater supplies for residents and to safeguard health, resources, and property in the vicinity of existing and potential water supply wells and springs. Septic tanks, sewage lagoons, active or abandoned mines, abandoned or unauthorized dumping areas, and underground storage tanks are some of the highest priority contaminant sources. Examples of other residential, commercial, industrial and municipal contaminant sources also are listed in the plans or their appendices.

The principal areas of concern for the Hopi wellhead protection program are the unconfined N-Aquifer in the Moenkopi area and springs emanating from the near-surface Toreva and Wepo formations. Since many of the springs used by Hopi villages emanate from the near-surface Toreva or Wepo Formation, protection of these areas from potential surface contamination is a priority for the tribe. Consequently, the Hopi wellhead protection manual recommends that the wellhead protection program also be applied to springs. In that document, the terms “well” or “wellhead” also include springs (Hopi Tribe Water Resources Program 1996). Prevention of contamination through wellbores in confined water supply wells also is an important issue undertaken through the Hopi wellhead protection program (Hopi Tribe Water Resources Program 1996).

3.7.1.4 Transmission Systems and Communication Sites

Regulatory programs pertaining to water resources along or at the Western Transmission System (WTS) and the Southern Transmission System (STS) include construction or operation/maintenance storm water protection plans, SPCC plans, and Rights-of-Way (ROWs) permit stipulations determined by authorizing agencies. For example, these may include requirements for erosion controls; vehicle and equipment parking related to floodplains, wetlands, or springs; location of staging or storage areas; channel protection measures at access road crossings; or the timing of work around surface flows. One example includes provisions in the U.S. Army Corps of Engineers Nationwide Permit 12 (Utility Line Activities) for transmission line crossings of Waters of the United States (U.S. Army Corps of Engineers 2012); another is the content/questionnaire in BLM (Bureau of Land Management) Standard Form 299 (Application for Transportation and Utility Systems and Facilities on Federal Lands) (BLM 2009a) and the corresponding Plan of Development guidelines for construction (e.g, “Earthwork” and “Stabilization, Rehabilitation and Revegetation”) and other operation and maintenance information requirements for a BLM ROW application (BLM 2009b).

3.7.2 Study Areas

The water resources study areas are located in a portion of the Colorado Plateau region of northeastern Arizona. **Figure 3.7-1** depicts the study areas. For groundwater resources, the study area includes the N-Aquifer footprint as it occurs in the lower San Juan and Colorado river basins of northeastern Arizona (**Figure 3.7-2**). The N-Aquifer is a major source of springs and potable water in the region; its study area occupies approximately 10,400 square miles. The groundwater study area is bounded on the north by the lower San Juan River, Lake Powell, and the Colorado River. It is bounded by Chinle Wash/Chinle Creek to the east, and elsewhere by the outer limit of the N-Aquifer as indicated on **Figure 3.7-2**. Hydrologic features overlying the N-Aquifer, including other groundwater-bearing zones, springs and seeps, stream channels, ponds, and other water supply features, are included in the assessment.

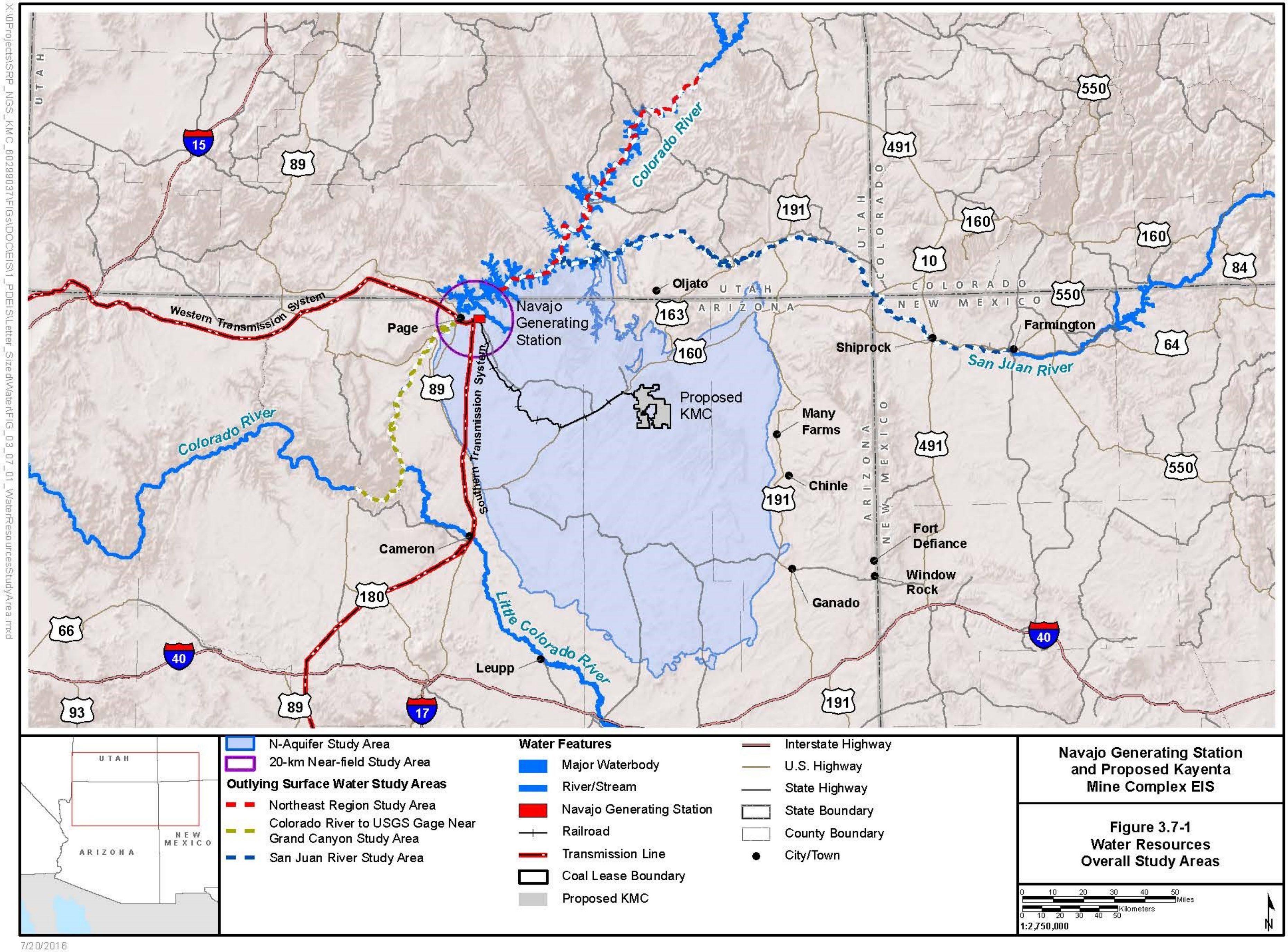

Figure 3.7-1
Water Resources
Overall Study Areas

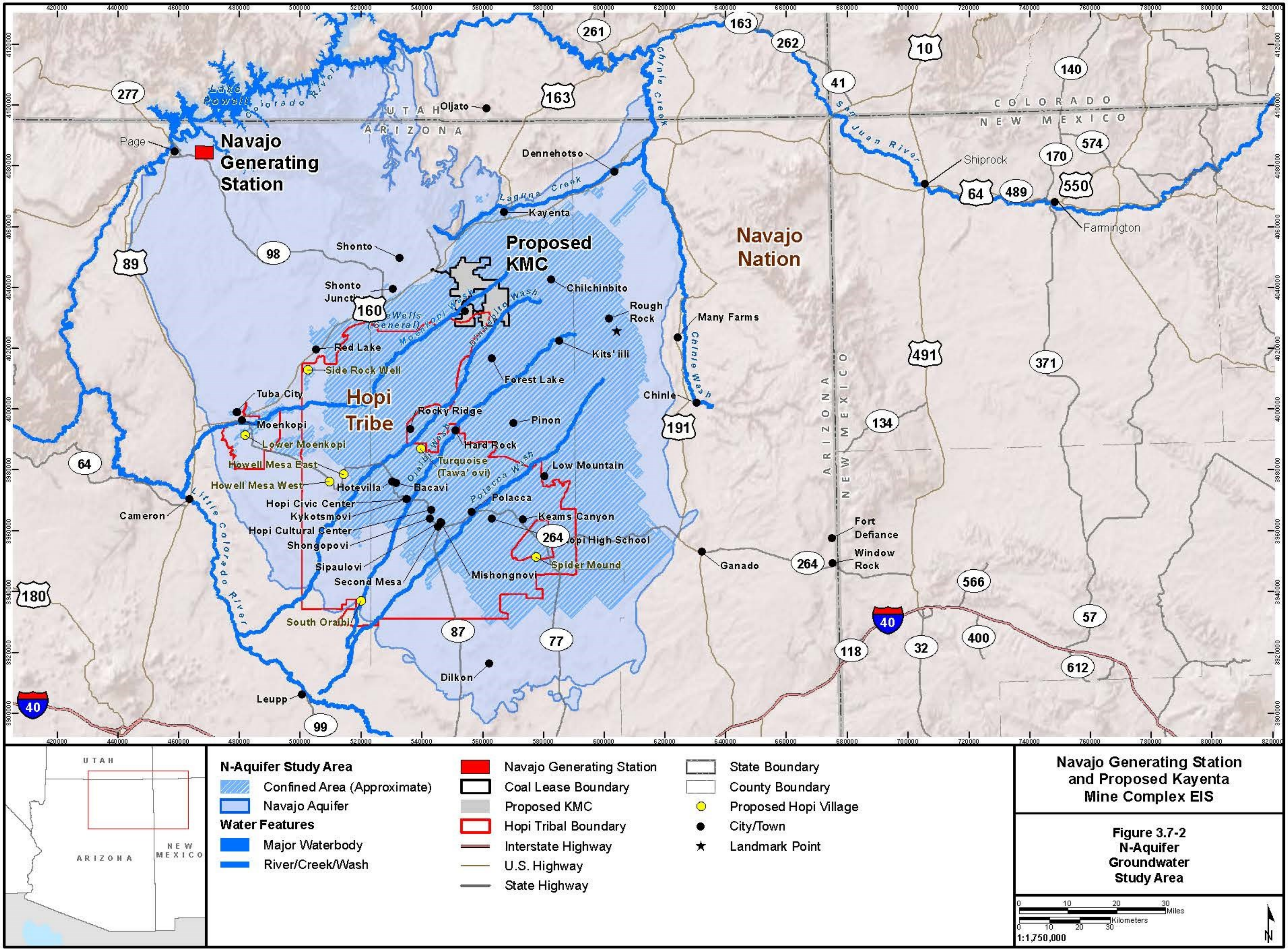

Figure 3.7-2
N-Aquifer Groundwater Study Area

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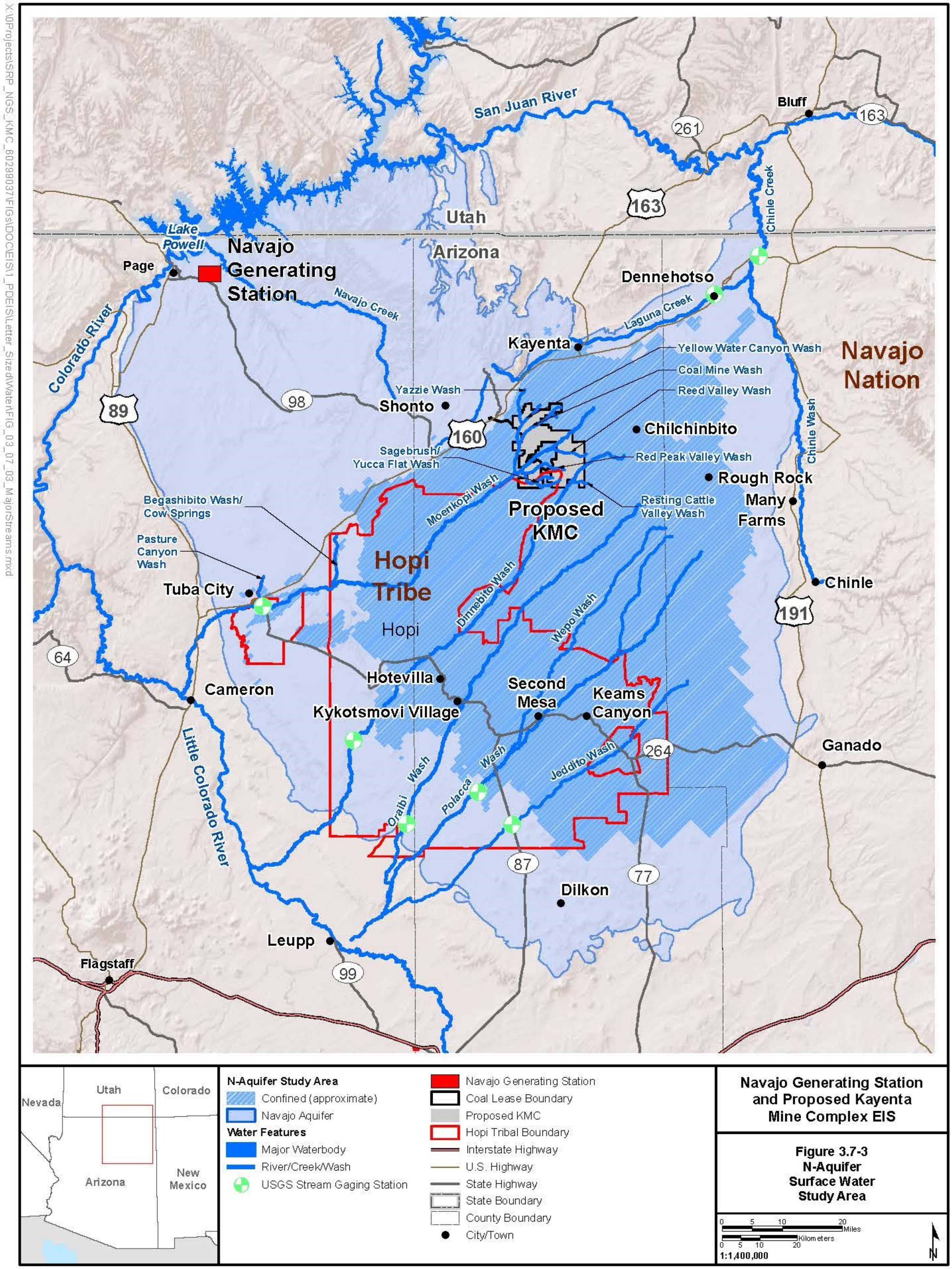


Figure 3.7-3
N-Aquifer Surface Water Study Area

3.7.2.1 Navajo Generating Station

Two surface water study areas also are shown on **Figure 3.7-1**. In coordination with the Ecological Risk Assessment (ERA) and Biological Resources assessments (Section 3.13), the NGS study area includes the Colorado and San Juan rivers as they enter Lake Powell, their courses through Lake Powell itself, and the Colorado River downstream of Glen Canyon Dam to the U.S. Geological Survey (USGS) streamgage at Lees Ferry (USGS 09380000). A 20-kilometer (km) radius from the NGS is included in that surface water study area.

3.7.2.2 Proposed Kayenta Mine Complex

For the proposed KMC, a separate surface water study area is defined in association with the N-Aquifer footprint. This surface water study area is bounded by USGS gages on channels draining the Black Mesa area. As shown on **Figure 3.7-3**, these include the gaging stations on Moenkopi Wash at Moenkopi (USGS 09401260), Dinnebito Wash near Sand Springs (USGS 09401110), Oraibi Wash near Tolani Lake (USGS 09400562), Polacca Wash near Second Mesa (USGS 09400568), and Jeddito Wash near Jeddito (USGS 09400583). The proposed KMC surface water study area also includes Laguna Creek (USGS 09379180) and Chinle Wash/Chinle Creek (USGS 09379200) draining to the San Juan River. Pasture Canyon, Begashibito Wash, and other tributaries to these major washes are included.

3.7.2.3 Transmission Systems and Communication Sites

For the transmission systems, the surface water study area follows the WTS and STS ROWs. Perennial, intermittent, and ephemeral streams cross the WTS and STS as depicted on **Figure 3.7-1**.

3.7.3 Affected Environment

The following Affected Environment sections are typically based on data collected from the period 2010 through 2014. The purpose of this time-frame is to identify existing conditions within the project area as a recent background for future alternatives. In some cases, longer time intervals and broader spatial coverage have been included here to better describe the resource setting and related factors. For the most part, additional water resource data for longer timeframes and regional aspects are further described in **Appendix WR-8** (Cumulative Water Resources Supplement), and in longer-term data summaries in other Water Resources appendices. Cumulative impact assessments (in Environmental Consequences) cover a broader timeframe, as well as other actions.

3.7.3.1 Regional Overview

3.7.3.1.1 Precipitation and Evaporation

Precipitation in the study area primarily falls during two parts of the year. Rainfall is greatest during the July through September monsoon season, and a relatively wet period also occurs during the winter months (December through March) (Arizona Department of Water Resources 2010b). Substantial variability occurs between individual years. Shifts between wetter and drier periods also are common on longer, 10- to 20-year (decadal) time scales (Arizona Department of Water Resources 2010b). Generally lower precipitation rates have occurred since about 1995.

Average annual precipitation generally varies with elevation in the study area. Historically, precipitation has been the greatest (approximately 14 inches a year) at the highest, northern edge of Black Mesa near Yale Point (Arizona Department of Water Resources 2010a). Average annual precipitation declines as the mesa slopes downward to the south and west. Generally between 10 to 12 inches are received annually at Piñon and between 8 to 10 inches at Kykotsmovi. At lower elevations, about 6.5 inches per year are received on average at Page, Tuba City and Leupp, and about 7 inches at Many Farms (Western Regional Climate Center 2015a). The mean annual precipitation increases eastward to about

9 or 10 inches at Chinle, Ganado, and on the Defiance Plateau. Mean annual precipitation is 7 to 8 inches per year in the Shiprock-Farmington area of New Mexico.

Widely scattered convective thunderstorms generally occur in the earlier summer months, and monsoonal rainfall events occur later in summer and early fall. Examples of precipitation totals by month are indicated in **Table 3.7-3**, where the changes from June to July values are notable.

Table 3.7-3 Average Monthly Precipitation at Selected Stations

Location[1]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kayenta	0.46	0.47	0.55	0.38	0.39	0.28	1.18	1.40	0.75	0.87	0.44	0.48
Pinon	0.59	0.68	0.61	0.48	0.13	0.23	1.22	0.77	1.07	1.4	0.54	0.98
Betatakin	1.09	0.95	0.94	0.75	0.46	0.34	1.37	1.63	1.2	1.18	0.9	1.16

[1] Periods of record vary.

Source: Western Regional Climate Center 2015a.

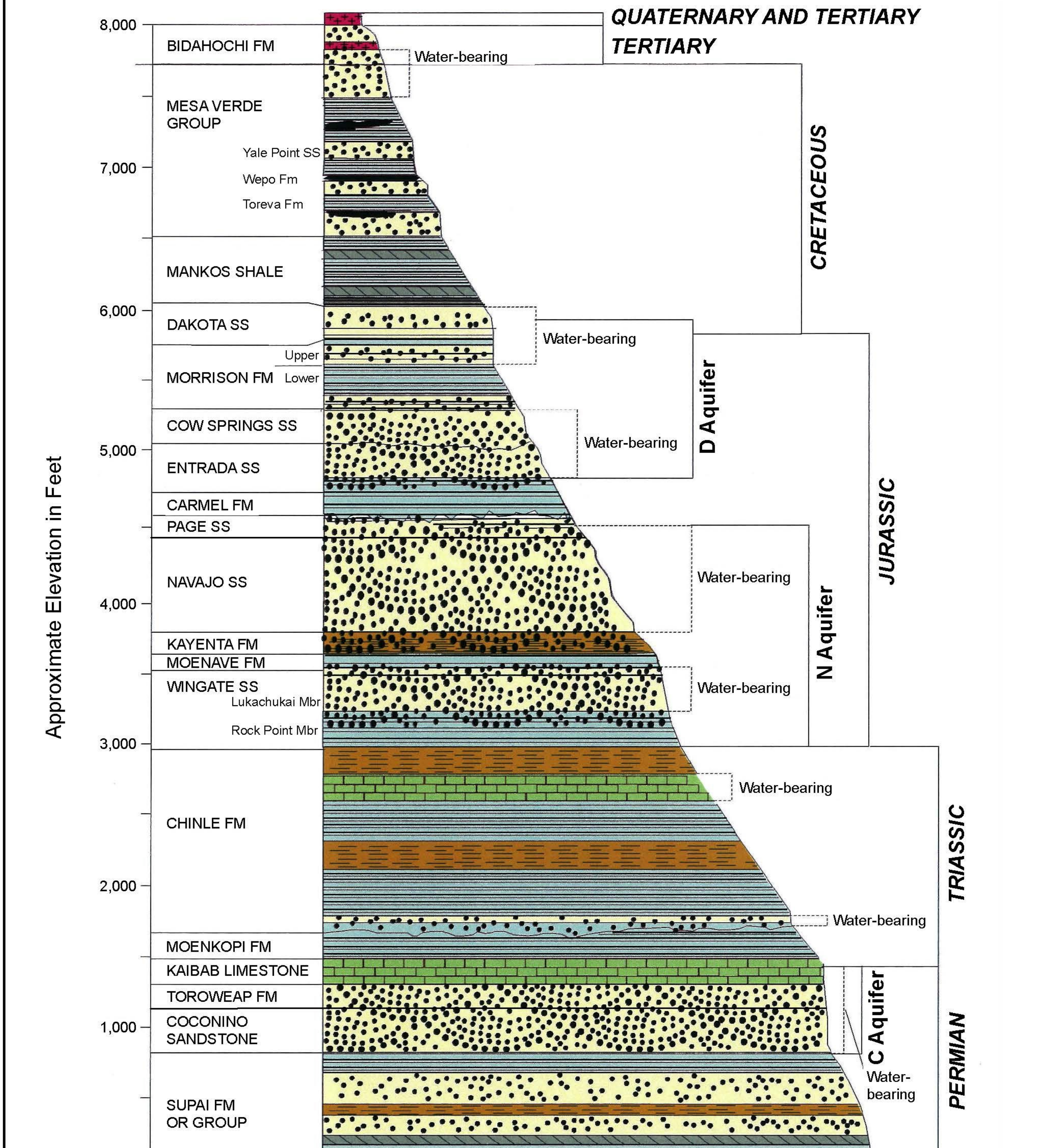
As discussed in Section 3.2, the National Climate Assessment (Walsh et al. 2014) shows a 10 to 15 percent reduction in local precipitation over northeastern Arizona when comparing the 1991 through 2012 annual average to the 1901 through 1960 annual average. A region-wide comparison was performed for this EIS to compare precipitation data from five federal stations: Betatakin, Grand Canyon, Page, Winslow, and Canyon de Chelly. The results of this comparison indicated that the period 1995 through 2012 had about 15 percent lower precipitation than 1970 through 1994, statistically significant at a 5 percent significance level.

Documentation of drought in the western Navajo/Hopi region is difficult, due to the variety of climatic and topographic characteristics and the sparseness of standardized weather stations. The recent drought began in about 1999, although some residents maintain that it started in 1996 or before (Redsteer et al. 2010). In the western Navajo Nation, below-normal rainfall was recorded beginning in 1994. It is possible that drought may have begun then in the drier western part of the Navajo Nation, and became more regionally extensive in following years (Redsteer et al. 2010). The frequency of wind, sand, and dust storms were indicated as being more common in the 1950s, and were noted to be increasing again in the 1990s.

In addition, substantial increases in evapotranspiration occurred during the warm seasons of the early 2000s, due to increasing temperatures (Redsteer et al. 2010). Annual pan evaporation averages approximately 80.6 inches at Page, approximately 84.7 inches at Winslow, and approximately 90.8 inches at Many Farms School (Arizona Department of Water Resources 2010a; Western Regional Climate Center 2015b). Assuming a pan coefficient of 0.70, annual evaporation losses from a free-water surface (such as a pond or lake) would be approximately 56.4 inches at Page, 59.3 inches at Winslow, and 63.6 inches at Many Farms. On a long-term average basis, evaporation and evapotranspiration losses are substantially greater than precipitation rates, creating the arid to semi-arid conditions in the study area. Surface water flows and groundwater recharge occur over relatively short periods when rainfall overrides evaporation and transpiration losses.

3.7.3.1.2 Groundwater

Groundwater resources in the study area consist of several aquifer zones. These are depicted on **Figure 3.7-4**.



*Source: Macy and Unema 2013.

Coal, Carbonaceous Siltstone, Mudstone
Massive Sandstone
Cross-Bedded Sandstone
Interbedded Siltstone, Mudstone, and Claystone
Limestone
Siltstone

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 3.7-4 General Aquifer Relationships

7/20/2016

The distribution and properties of geologic materials underlying the NGS/Kayenta Mine area control the occurrence and movement of groundwater in the project study area. **Figure 3.7-4** depicts the general stratigraphic arrangement of all the consolidated geologic units in the regional (cumulative) study area. Only some of these are relevant to the individual project components (e.g., the generation station or the mine). In particular, only the Carmel Formation and deeper formations (including the N-Aquifer) underlie the NGS and outlying parts of the cumulative study region. Most of the stratigraphic column depicted on **Figure 3.7-4** underlies the Kayenta Mine. Additional information about these units is presented in **Appendices WR-5** and **WR-6**.

Stratigraphic units can be grouped based on their ability to retard or promote groundwater movement. Those that limit or prevent groundwater movement are called aquicludes or aquitards. Those that allow or promote groundwater movement, where saturated, are called aquifers. Hydrostratigraphic units in the NGS/Kayenta Mine area include the following:

- Wepo and Toreva Aquifers;
- Mancos Shale (aquitard);
- D-Aquifer System (Dakota, Morrison/Cow Springs, Wanakah, Entrada);
- Carmel Siltstone (aquiclude);
- N-Aquifer System (Page, Navajo, Kayenta, Moenave, Wingate);
- Chinle and Moenkopi Formations (aquiclude);
- C-Aquifer (Kaibab, Coconino);
- Supai Formation (aquiclude); and
- R-Aquifer System (Redwall/Muav).

The Wepo Formation is at the surface in the PWCC leasehold and, with local stream alluvium, comprises the shallow groundwater aquifer system. These aquifers supply water to windmills and groundwater to seeps and springs. Mining activities remove coal from the Wepo Formation. The Toreva Formation is an additional water-bearing zone underneath the Wepo Formation, but is not affected by mining. The Toreva Formation provides water to wells and springs at lower elevations on Black Mesa.

The Mancos Shale is a Cretaceous claystone and siltstone from 500 to 1,800 feet thick in the study area. It is low-permeability and serves as an effective aquitard, significantly limiting groundwater movement from the overlying Wepo and Toreva aquifers to the underlying D-Aquifer.

The Jurassic-Cretaceous sedimentary rocks of the San Rafael Group, including the Dakota Sandstone, Morrison Formation and Entrada Sandstone, comprise the D-Aquifer System over Black Mesa and isolated mesas of the Kaibeto/Rainbow Plateaus. The D-Aquifer System is composed of only the Dakota Sandstone and Morrison Formation northeast of the Chinle Wash drainage. The aquifer is not present in the NGS area, where the uppermost unit is the Carmel Formation. On Black Mesa, windmill wells are mainly constructed in the D-Aquifer.

The Carmel Formation is a siltstone with some sandstone of Middle Jurassic age that ranges from zero to about 300 feet in thickness in the cumulative study area. Over much of Black Mesa, including the coal lease area, the unit is a siltstone greater than 120 feet thick and is an effective aquiclude; in these areas the Carmel Formation acts as a confining layer to the underlying N-Aquifer. In the southern part of Black Mesa where it is sandier and less than 120 feet thick, it allows more downward migration of groundwater from the D- to N-Aquifer than in other areas (Truini and Macy 2006). The Carmel Formation is at the surface at the NGS (**Appendix 1B**).

The N-Aquifer includes: the Triassic-Jurassic Wingate Sandstone, Moenave Formation, Kayenta Formation, Navajo Sandstone and Page Sandstone of the Glen Canyon Group. The Page Sandstone is essentially identical to the Navajo Sandstone, but is separated from it by a regional erosion surface and is found (overlying the Navajo Sandstone) only beneath the isolated mesas of the Kaibeto/Rainbow Plateau near Page, Arizona. The Page Sandstone is typically discussed in concert with the Navajo Sandstone. The Moenave Formation is found only in the far southwest of the Black Mesa Basin and typically is discussed with the Kayenta Formation. The Wingate Sandstone, Kayenta Formation, and Navajo Sandstone occur over much of the study area. Together these sequences comprise the N-Aquifer, which is the principal source of industrial (Kayenta Mine) and municipal water in the study area.

Beneath the N-Aquifer lies the Chinle Formation, which consists mainly of siltstone, silty sandstone, and mudstone, occasionally interbedded with sandstones. As an aquiclude, it limits or prevents groundwater movement between the N-Aquifer and the underlying C-Aquifer. Within the study area, the N- and underlying C-Aquifer systems are separated by approximately 1,000 feet of relatively impermeable Chinle and Moenkopi Formations (OSMRE 2011a). There is little hydraulic communication between the two aquifer systems.

The C-Aquifer, comprised of the Permian Kaibab Limestone and Coconino Sandstone, underlies much of the study area. However, it is buried to a depth of approximately 5,000 feet beneath the Kayenta Mine and separated from the overlying N-Aquifer by approximately 1,800 feet of siltstone and claystone of the Chinle and Moenkopi Formations. Beneath the NGS, the C-Aquifer, if present, is at a depth of more than 2,000 feet below ground surface (bgs). North of the Little Colorado River, the C-Aquifer is generally too deep to be an economic water source for most supplies, or it is otherwise unsuitable for most uses due to elevated concentrations of Total Dissolved Solids (TDS) (Arizona Department of Water Resources 2010b). While the C-Aquifer is a viable source of potable water south of the Little Colorado River, it is not proposed for use at the NGS or Kayenta Mine. Therefore, it would not be impacted by operations at these facilities, and is not considered further.

The Supai Formation is an aquiclude between the C- and R-Aquifers. It consists of alternating sandstone and siltstone units.

The deepest aquifer system in the study area, referred to as the “R-Aquifer,” is comprised of the Cambrian-Mississippian Redwall and Muav Limestone Formations. In the study area these units are not exposed at the surface except in the gorges of the Little Colorado and Colorado Rivers where high salinity water (over 3,000 milligrams per liter [mg/L]) from the aquifer discharges to the rivers. No water supply wells penetrate the R-Aquifer beneath the NGS/Kayenta Mine facilities; therefore, this aquifer system is not further addressed in this document.

3.7.3.1.3 Surface Water

Surface water resources in the study area include Lake Powell along its Colorado and San Juan river arms, the Colorado River downstream of Lake Powell to the USGS streamgage at Lees Ferry (USGS 09380000), and several major drainages on or near Black Mesa. Major channels in the Black Mesa region that drain to the Little Colorado River include Moenkopi Wash, Dinnebito Wash, Oraibi Wash, Polacca Wash, and Jeddito Wash (**Figure 3.7-3**). Pasture Canyon, and Begashibito and Shonto washes are major tributaries to Moenkopi Wash in the Tuba City/Moenkopi area. Along the north side of Black Mesa, Laguna Creek drains to Chinle Creek, which in turn drains to the San Juan River.

The Colorado River is impounded by Glen Canyon Dam near Page, Arizona, forming Lake Powell. At its nominal full pool elevation (3,700 feet above mean sea level [amsl]), Lake Powell extends 186 miles up the Colorado River and 75 miles up the San Juan River (Ferrari 1988). **Table 3.7-4** indicates other reservoir characteristics. Lake Powell characteristics are described further in **Appendix WR-8**.

Table 3.7-4 Lake Powell Magnitudes

Reservoir Pool Status	Water Surface Elevation (feet amsl)	Capacity (acre-feet)	Extent (acres / square miles)
Full Pool	3,700	26.2 million	160,784 / 252.2
Lowest Historical (2005)	3,555	9.8 million	73,787 / 115.3

Source: Reclamation 2007.

A century of river flow records indicates that long and severe droughts are not unusual in the American Southwest (Lindsey 2015). For example, during the 15-year period from 2000 to 2014, the unregulated inflow to Lake Powell was above average in only three out of the 15 years. The period 2000 through 2014 is the lowest 15-year period recorded since the closure of Glen Canyon Dam in 1963. Since the year 2000, the average unregulated water-year inflow has been approximately 8.4 million acre-feet, or 78 percent of the 30-year average from 1981-2010 (Reclamation 2015a).

On Black Mesa, runoff from precipitation creates the greatest streamflows in the washes. Comparatively minor flows result from snowmelt. Most flows occur from convective thunderstorms in the earlier summer months, and from monsoon-related frontal rainfall events later in summer and early fall. Because of this, the uppermost reaches and tributaries of Moenkopi Wash, Dinnebito Wash, Oraibi Wash, and others are ephemeral, with short periods of flow in response to runoff. In scattered locations where aquifers contribute seasonal baseflows to the stream channels, the washes exhibit flowing water intermittently. Evapotranspiration and seepage into the deeper alluvial deposits typically limits such reaches to short, isolated stream segments. Some washes are perennial at lower elevations, with small year-round flows from groundwater contributions. Lower Moenkopi Wash, Pasture Canyon, lower Dinnebito Wash, and lower Polacca Wash have small perennial flows.

Based on historical research, substantial reductions in the number and length of perennial stream reaches have been recorded since the mid-1900s (Arizona Department of Water Resources 2008; Cooley et al. 1969; Redsteer et al. 2010). Historical riparian alterations are thought to have begun in the 1940s, due to the adaptation of more salt- and drought-tolerant vegetation to the drier conditions (Redsteer et al. 2010). Investigators also noted that portions of Laguna Creek, upper Polacca Wash, lower Moenkopi Wash, middle Jeddito Wash, and lower Chinle Wash formerly were perennial in the early to mid-1900s, but had become dryer by the 1960s (Cooley et al. 1969; Redsteer 2012). Depending on location, parts of these reaches are intermittent or ephemeral now. Changes to ephemeral conditions became more extensive along Moenkopi Wash and Chinle Wash after 1960. Interviews with numerous tribal elders indicated a long-term decrease in annual snowfall, a decline in surface water features and water availability, and the disappearance of springs since about 1994 (Redsteer et al. 2010).

Precipitation cycles and changes in streamflow regimes have been widely recognized in the American Southwest (Hereford 2007; Karlstrom 1988; National Research Council 2007). Along with the wet and dry climate cycles, flow durations in stream reaches also are subject to complex relationships between arroyo cutting, sediment infilling, channel responses to floods, and adjacent groundwater levels. All of the streams store and transport large volumes of sediment along their channels. Bank erosion and headcuts are common throughout the study areas.

In addition to rivers, streams, and washes, small stock ponds are scattered throughout the study area. On Black Mesa, they are located on tribal lands outside the leasehold, or are part of mine water controls within the leasehold. A number of stock ponds, and diversions that direct runoff to them, are not project-related and are located downstream of the leasehold along Dinnebito Wash. These downstream features affect flow conditions below the leasehold, which are of interest based on public scoping inputs. Retention structures on the leasehold have either a temporary or permanent status, depending on their function during mining or after reclamation. In addition to ponds, tanks at windmills supply water for livestock at scattered locations.

3.7.3.2 Navajo Generating Station

The NGS is located approximately 60 miles northwest of the Kayenta Mine on the south side of the Colorado River near Page, Arizona. The plant site is about 3 miles from Lake Powell. The facilities are further described in Chapter 1.0 and **Appendix 1B**. In addition to other topics, parts of **Appendix 1B** that are of major interest to water resources include:

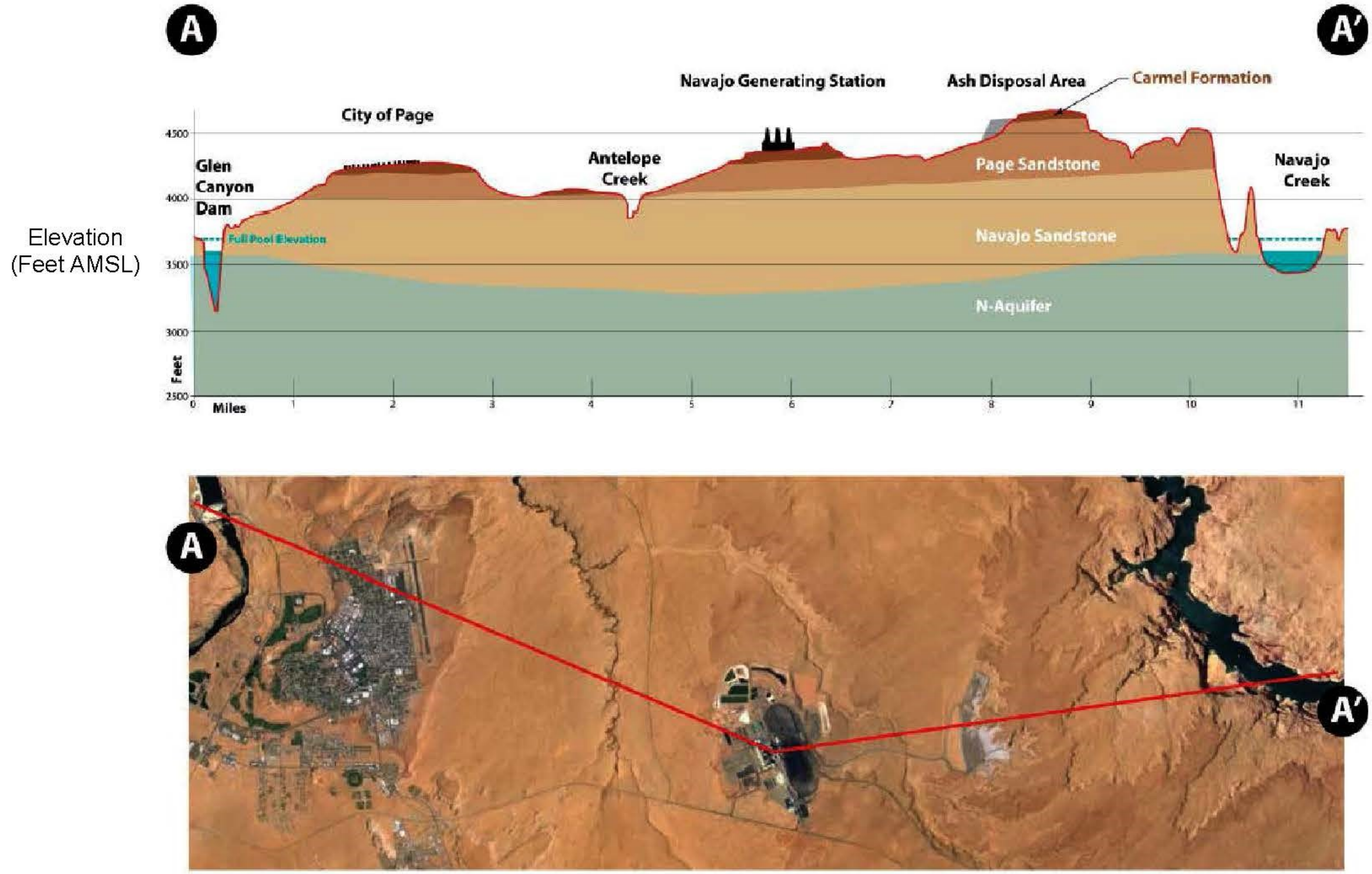
- The “Water Use and Management in Plant Operations” text section;
- The “Oil and Chemical Storage” text section;
- The “Wastewater Management” portion of the “Waste Management” text section;
- Supplemental **Appendices B** and **C** (respectively, the CCR Ash Disposal Landfill Requirements, followed by the Groundwater Protection Plan);
- Groundwater Protection Plan supplemental **Appendices C(1)** and **C(2)**, which respectively include the “Perched Water Dewatering Work Plan” and results from the NGS groundwater monitoring program (1978 to the present);
- Best management practices and mitigation measures for water quality in supplemental **Appendix E**.

3.7.3.2.1 Groundwater at NGS

3.7.3.2.1.1 Aquifer Configuration

The Mesa Verde and D-Aquifer zones are absent in the NGS area; the Carmel Formation is at the surface beneath most of the NGS facilities and, where present, forms a thin veneer over the Page Sandstone, which in turn overlies the Navajo Sandstone (**Figure 3.7-5**). The Carmel Formation is absent beneath the Solid Waste Landfill and Ash Disposal Area, which are underlain by the Page and Navajo sandstones (**Appendix 1B**). In some areas, the Carmel Formation is overlain by dune sand up to about 15 feet thick. The dune sands are unconsolidated wind-blown materials eroded from various formations (primarily the Navajo Sandstone). The Carmel Formation itself ranges in thickness from zero to about 70 feet. The Page Sandstone is not differentiated from the Navajo Sandstone in monitor well logs; however, it is separated from the Navajo Sandstone by an unconformity. The Navajo Sandstone is approximately 1,400 feet thick in the NGS area and is unconfined, with the water level at a depth of about 900 feet bgs. Due to the depth of groundwater, no wells produce water from the Navajo Sandstone in the NGS area; the plant and nearby City of Page rely on surface water from the Colorado River to meet processing and potable needs (**Appendix 1B**). The Black Mesa & Lake Powell Railroad starts at the PWCC leasehold and travels northwest 78 miles to the NGS, as shown in Chapter 1.0. The railroad traverses the unconfined portion of the N-Aquifer over most of its length. Water levels in the aquifer in this area range near the land surface at the shallowest point near Cow Springs, to about 900 feet bgs at its terminus at the NGS.

Prior to 1981 groundwater in the N-Aquifer flowed toward the Colorado River. However, due to the filling of Lake Powell (starting in 1960), water levels in the aquifer beneath the NGS have risen from 40 to 80 feet since the early 1980s. Groundwater flow also has changed from southeast–northwest, to northeast–southwest (**Appendix 1B**).



Source: Salt River Project 2015

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 3.7-5

Stratigraphy at NGS

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No groundwater supplies are used at NGS. A number of shallow and deep monitoring wells have been constructed since the 1970s. These are further described in the Operation and Maintenance Plan (**Appendix 1B**). Three deep wells monitor the N-Aquifer. General characteristics of the three deep wells used to monitor the N-Aquifer at NGS are summarized in **Table 3.7-5**. The depths of open boreholes vary.

Table 3.7-5 Deep Monitoring Wells at NGS

NGS Deep Well	General Location [1]	Land Surface Elevation (feet amsl)[2]	Total Well Depth, (feet bgs)[3]	Depth to Water, (feet bgs)[3]	Water Elevation, (feet amsl)[2,4]
DW-1	Northwest part of plant area, near plant perimeter at wastewater management ponds	4,298.6	1,200	833.2	3,465.4
DW-2	Inside the southwest part of the rail loop	4,366.2	1,500	906.0	3,460.2
DW-3	Northwest corner of dry ash disposal area	4,434.1	1,500	918.3	3,515.8

[1] These features are depicted on figures accompanying Chapter 1.0.

[2] Elevation in feet, referenced to above mean sea level (amsl).

[3] Depth in feet below ground surface (bgs).

[4] Data from May, 2015.

Source: **Appendix 1B**.

Data from these deep monitoring wells at NGS indicate that the groundwater levels in the N-Aquifer in the plant vicinity have risen about 1 to 2 feet per year (**Appendix 1B**). A Reclamation study in 1969 indicated that groundwater levels will rise to an elevation of approximately 3,550 to 3,600 feet amsl beneath NGS, in response to recharge from Lake Powell (**Appendix 1B**). Assuming that the observed water level rises are due to lake-generated aquifer recharge and using 1 to 2 feet per year rate of rise, hydraulic equilibrium would be reached in the next 50 to 100 years based on the earlier Reclamation study (**Appendix 1B**). If this occurs and the earlier predictions are correct, N-Aquifer water would still be approximately 700 to 766 feet or more bgs at the plant site, and approximately 824 feet or more below the ground surface at Well DW-3 at the dry ash disposal area.

3.7.3.2.1.2 Aquifer Parameters

Estimated hydraulic conductivity of the hydrogeologic units beneath the NGS area is summarized in **Table 3.7-6**.

Table 3.7-6 NGS Unit Hydraulic Conductivities

Hydrologic Unit	Hydraulic Conductivity (feet/day)
Dune Sand	2.5 to 4.7
Carmel	<0.003 to 0.25
Page/Navajo Sandstone	0.03 to 1.1

Source: **Appendix 1B**.

3.7.3.2.1.3 Groundwater Quality

Prior to the construction of the NGS, the upper hydrologic units were unsaturated, with the water table being in the N-Aquifer at a depth of about 900 feet bgs. However, leakage from previously unlined ponds and other sources at the site has created a local perched water table in the low permeability layers of the Carmel Formation beneath portions of the plant site. In 2012, depth-to-water in this perched system ranged from about 7 to more than 20 feet bgs. Water levels are reported to be dissipating in the plant pond areas since the ponds were lined. However, leakage appears to be continuing in the cooling tower area.

As described in the Groundwater Protection Plan (Appendix C to **Appendix 1B**) and its supplemental Appendix 1 (Perched Water Dewatering Plan), routine inspections, pond leak detection, perched water recovery and monitoring, N-Aquifer monitoring, and mitigation activities have been instituted and coordinated with the USEPA. Dewatering activities have been instituted and are ongoing, and will recover perched water beneath the plant via recovery wells. Extracted water is reclaimed into plant processes. Ongoing activities will address the factors contributing to the presence of leaked water, which is retained in the low permeability Carmel Formation. In general, activities will include upgrades to the pond liners, upgrades to linings in the drainage ditches of the ash dewatering area, repairs to cooling tower basins, and other practices as may result from existing programs and implementation of the Groundwater Protection Plan. The Groundwater Protection Plan further describes water management facilities at NGS, their inspections and monitoring, emergency contingency plans, and the closure and post-closure care planning and reporting efforts. These activities are coordinated with the appropriate USEPA regulatory program. Included in these are clear protocols for sampling, analysis, and validation; specific water quality standards that can be used to trigger corrective actions; clear enforceable action levels based on federal standards; and reporting requirements.

Supplemental Appendix 2 to the Groundwater Protection Plan also details geologic factors and monitoring results at NGS. Water quality in the deep N-Aquifer wells has been regularly monitored since the mid-1990s. Background samples were collected in 1979 and 1981. With the exception of a temporary spike in well DW-2, TDS and sulfate have remained essentially at background levels, ranging from 100 to 160 mg/L and 10 to 45 mg/L, respectively. Well DW-2 was found to be leaking perched water below the surface casing and was rehabilitated in 1989 by installing a casing liner to a depth 660 feet bgs. Following the installation of the casing liner, TDS and sulfate concentrations returned to background levels (**Appendix 1B**). There is no evidence of a long-term increase in TDS concentrations in the deep wells, either from plant operations or from Lake Powell.

N-Aquifer samples at NGS also indicate concentrations of nitrate-nitrogen and fluoride are relatively low, and are less than the USEPA Maximum Contaminant Levels for drinking water (10 mg/L and 4 mg/L, respectively) (**Appendix 1B**). Nitrate levels generally are less than 3 mg/L; fluoride levels generally are less than 1 mg/L. Recent (2011–2012) concentrations of trace elements, including arsenic, barium, cadmium, chromium, lead, and selenium are less than the drinking water Maximum Contaminant Levels, and are below appropriate laboratory detection levels in the majority of samples. For example, the Maximum Contaminant Level for arsenic is 0.1 mg/L, and concentrations in N-Aquifer samples from NGS range from less than 0.002 mg/L to 0.0062 mg/L. Selenium concentrations are all below the 0.002 mg/L detection limit, much less than the selenium Maximum Contaminant Level of 0.05 mg/L. Mercury concentrations are all below the 0.0002 mg/L detection limit, much less than the mercury Maximum Contaminant Level of 0.002 mg/L.

3.7.3.2.2 Surface Water Features and Management at NGS

3.7.3.2.2.1 On-site Configuration

No groundwater supplies are used at NGS. NGS withdraws all of its water supply from Lake Powell through its pump station and associated pipeline. NGS has an annual allocation of 34,100 acre-feet per year for consumptive use. Over the past 15 years, annual water use at NGS has varied from about 26,000 up to 29,000 acre-feet per year.

The only natural surface water feature within or near the plant perimeter is a sandy, ephemeral tributary to Antelope Canyon. This passes through the area east of the main plant facilities, and about one-third of a mile west of the dry ash disposal site. No flow records are available for the tributary, and it flows only rarely in response to substantial rainfall. Still smaller ephemeral side-branches occur along the southern edge of the dry ash disposal site, but are isolated from it by bedrock outcrops, an engineered embankment with a bedrock foundation, and runoff retention berms on nearby soil surfaces. Other surface water components and related management at or near the NGS (**Appendix 1B**) consist of:

- NGS make-up water intake and pipeline from Lake Powell;
- On-site storage ponds and fluid routing fixtures (piping, ditches) involved in storing and recycling water used in plant activities; and
- Stormwater collection and detention structures (ditches, ponds); and
- Ash disposal site surface run-on and run-off controls as required by the CCR rule (40 CFR Part 257.81)

Monitoring and inspections of the water management facilities, which includes the public water system, are regularly carried out in conformance with NGS environmental programs and applicable federal rules and regulations (e.g., Safe Drinking Water Act). Contingency plans reflect pond capacity thresholds or alert levels, and triggers involve fluid management responses, communications and reporting protocols, staff assignments, and documentation of all analyses, repairs and training. Additional descriptions of plant facilities and activities at NGS are presented in the Operation and Maintenance Plan (**Appendix 1B**), and in the companion groundwater description for the plant. By the proposed project start in 2019, SRP will have designed run-on and runoff controls for the ash disposal landfill incorporating the required design storm (e.g., a 25-year, 24-hour event); will have obtained plan certification from a qualified registered Professional Engineer; and will have constructed the surface water controls in compliance with CCR regulations.

3.7.3.2.2.2 Lake Powell and River Water Quality

Baseline water quality conditions for Lake Powell, the San Juan River, and the Colorado River upstream and downstream of the reservoir have been summarized from available state and federal data, and from project-specific studies conducted for the respective ERA (Ramboll Environ 2016a,b,c,e). Project specific studies emphasized several geographic extents, including a 20-km radius around the NGS, a 150-km radius, and several river reaches of interest (**Figure 3.7-1**). The NGS Sampling Investigation Report indicates that concentrations of key Constituents of Potential Ecological Concern are consistent with or below background concentrations for the area within 150 km around the NGS and within the State of Arizona (Ramboll Environ 2016a). More water quality data for the Colorado River, San Juan River, and Lake Powell in the overall surface water study area are included in **Appendix WR-8** and the ERA documentation.

With respect to total metals analysis, the concentrations observed for many constituents in Lake Powell are similar to those seen in the Colorado River (Ramboll Environ 2016e). There are some exceptions among total metals, such as aluminum, antimony, cobalt, iron, and thallium. These were detected in the lake samples but not in the river samples. Also the total concentrations of copper, lead, manganese vanadium, and zinc were noted to be a factor of five (or more) higher in Lake Powell than the Colorado River. No total metals were identified with higher concentrations in the Colorado River compared to Lake Powell. Importantly, there were no particularly significant differences noted that may not exist in any natural environment (Ramboll Environ 2016e).

With respect to dissolved metals, data indicate that maximum concentrations for many constituents are consistent between Lake Powell and the Colorado River. There are some exceptions, such as dissolved antimony, beryllium, cadmium, chromium, cobalt, lead, manganese, silver, and thallium, which were detected in dissolved phase in Lake Powell but not in the Colorado River. Dissolved aluminum, vanadium, and zinc had slightly higher concentrations in Lake Powell compared to the Colorado River. Importantly, similar to the total metals, overall dissolved concentrations are relatively similar between the water-bodies, and there are no particularly significant differences noted that may not exist in any natural environment (Ramboll Environ 2016e). Within the 20-km radius study area around the NGS (**Figure 3.7-6**), surface water resources consist of Lake Powell, its local tributary Navajo Creek, and the Colorado River extending to slightly below Lees Ferry (downstream of Glen Canyon Dam). **Table 3.7-7** summarizes concentrations of selected water quality constituents within Lake Powell and its nearby major tributaries (Colorado River, San Juan River). In the table below, sampling stations within the 20-km radius study area include Padre Bay, Lone Rock Beach, Stateline Marina, Antelope Point Marina, and the Colorado River at Lees Ferry (**Figure 3.7-6**). More inclusive water quality information for the Colorado River, San Juan River, and Lake Powell in the overall study area is included in **Appendix WR-8**.

3.7.3.3 Proposed Kayenta Mine Complex

3.7.3.3.1 Groundwater at the Proposed KMC

The deep aquifer systems of interest to this EIS are the D- and N-Aquifers. These aquifers supply water to Navajo and Hopi communities and the proposed KMC. In the overall groundwater study area, these aquifers also supply water to numerous windmill-powered wells for stock watering. The extent and configuration of these aquifer systems are further illustrated on figures in **Appendix WR-6**.

In the proposed KMC area, the N-Aquifer is the primary source of water to various users. In addition, the D-Aquifer is estimated to have historically contributed approximately 130 acre-feet per year to the total mine water supply (OSMRE 2011a). Currently the mine withdraws groundwater from seven wells that penetrate through the D-Aquifer to the N-Aquifer. Until recently, eight wells were used, but one (NAV5) that was not being used has been plugged to prevent downward movement of poorer quality water from the D-Aquifer to the N-Aquifer. As of September 2015, there were two wells (NAV4 and NAV7) that were open to both the D- and N-Aquifers at the proposed KMC. Migration of D-Aquifer water to the N-Aquifer through the wellbores at these locations has the potential to impact N-Aquifer water quality. This concern is further addressed in the Environmental Consequences section. Based on the issue, PWCC has modified these two wells to minimize the inflow of water from the D-Aquifer. NAV4 has been rehabilitated, and NAV7 is completely reclaimed and unusable. Under the Proposed Action or any alternative, there will be no open D-Aquifer zones in PWCC pumping wells.

3.7.3.3.1.1 N-Aquifer

The N-Aquifer includes the Navajo Sandstone, and deeper sandstones of the Kayenta Formation, and the Lukachukai member of the Wingate Formation (**Figure 3.7-4**). Drilling records from installation of the PWCC N-Aquifer supply wells in the coal lease areas indicate that the top of the Navajo Sandstone occurs at depths ranging from 2,330 to 2,990 feet bgs. As mentioned previously, the N-Aquifer generally is separated from the overlying D-Aquifer by the Carmel Formation. Other formations above the N-Aquifer, as listed previously and depicted on **Figure 3.7-4**, separate it from other mining activities near the land surface.

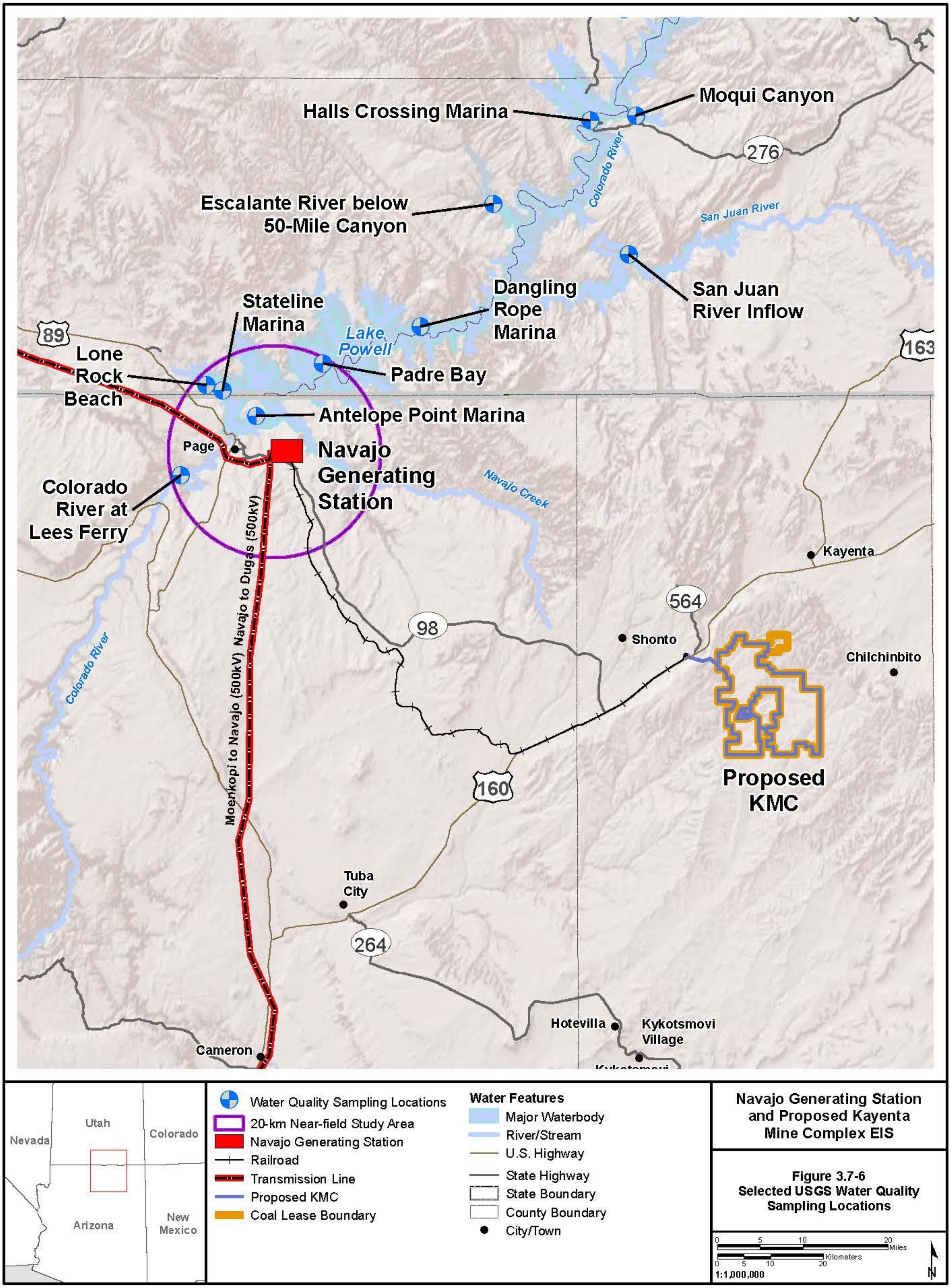


Figure 3.7-6
Selected USGS Water Quality Sampling Locations

Table 3.7-7 Average USGS Water and Lakebed Concentrations for Selected Constituents, Lake Powell and Selected Tributaries

Lake Powell Sites[1, 2]				
Marinas	**Halls Crossing (M2)**	**Dangling Rope (M3)**	**Antelope Point (M5)**	**Stateline (M6)**
Arsenic (D), water, µg/l	1.5	1.5	1.6	1.7
Mercury (D), water, µg/l	0.0005	0.0007	0.0006	0.0007
Selenium (D), water, µg/l	1.3	1.5	1.9	2.0
pH, water, standard units [3]	8.11 – 8.86	7.88 – 8.54	8.15 – 8.38	8.35 – 8.40
Arsenic (T), lakebed, µg/g	2.6	2.8	9.6	2.0
Mercury (T), lakebed, µg/g	0.002	0.0054	0.050	0.0033
Selenium (T), lakebed, µg/g	<0.6	0.7	1.0	<0.3
High Use Sites	**Moqui Canyon (HU5)**	**Escalante River at 50-mile Canyon (HU7)**	**Padre Bay (HU9)**	**Lone Rock Beach (HU11)**
Arsenic (D), water, µg/l	1.5	1.5	1.5	1.6
Mercury (D), water, µg/l	0.0004	0.0006	0.0006	0.0005
Selenium (D), water, µg/l	1.5	1.2	1.7	2.0
pH, water, standard units [3]	8.07 – 8.88	7.89 – 8.60	7.95 – 8.49	8.32 – 8.46
Arsenic (T), lakebed, µg/g	3.0	12.0	3.8	1.4
Mercury (T), lakebed, µg/g	0.0086	0.027	0.0073	0.0038
Selenium (T), lakebed, µg/g	0.8	0.6	0.6	0.4
River Sites[1,2]				
	San Juan River Inflow	**Colorado River below Big Drop #3 Rapids**	**Colorado River above Dark Canyon**	**Colorado River at Lees Ferry**
Arsenic (D), water, µg/l	1.2	1.6	1.8	1.4
Mercury (D), water, µg/l	0.0007	ND	ND	ND
Selenium (D), water, µg/l	1.1	3.1	3.2	1.7
pH, water, standard units[3]	8.40 – 8.46	7.32 – 8.83	7.42 – 8.84	7.90 – 8.30

[1] Values are arithmetic averages of multiple field samples and/or laboratory splits.

[2] For arsenic, mercury, and selenium, the aquatic use chronic standards are as follows (Arizona Department of Environmental Quality 2016; NNEPA 2008; Utah Department of Environmental Quality-Division of Water Quality [UDEQ-DWR] 2016):

- Arsenic, dissolved, micrograms per liter: 150 (NNEPA); 150 (Utah); 150 (Arizona)
- Mercury, dissolved, micrograms per liter: 0.001 (NNEPA); 0.012 (Utah); 0.01 (Arizona)
- Selenium, dissolved (D) or total (T): micrograms per liter: 2.0 D (NNEPA); 4.6 D (Utah); 2.0 T (Arizona)

[3] Values for pH are shown as ranges from discrete measurements.

D: dissolved fraction; T: total recoverable; µg/L: micrograms per liter; µg/g: micrograms per gram; < signifies "less than"; ND: not detected.

Source: Hart et al. 2012; Schonauer et al. 2014; USGS-NWIS 2015; UDEQ 2015.

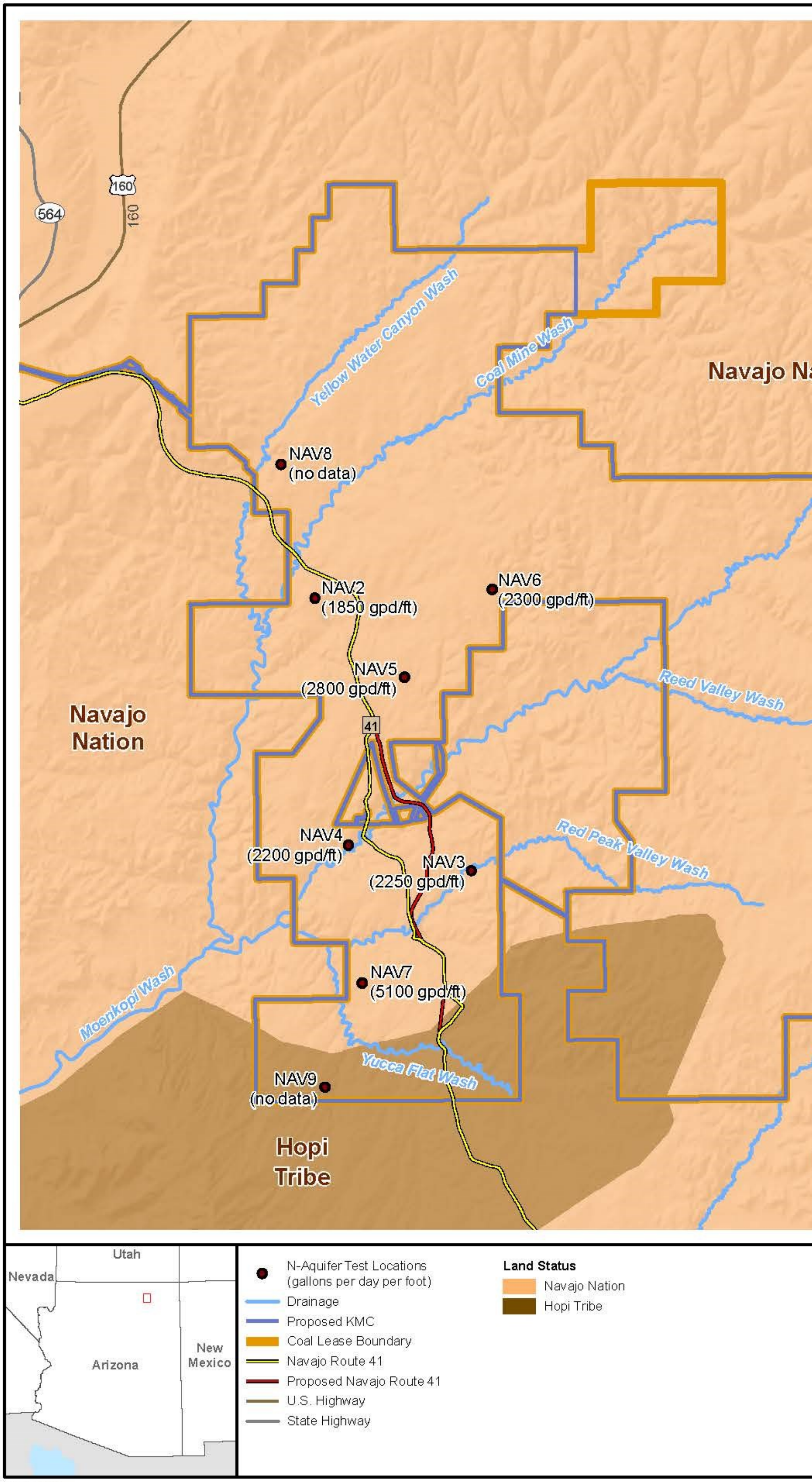
Figure 3.7-7 shows values of N-Aquifer transmissivities on the proposed KMC. Transmissivity is a hydraulic property that describes the amount of water flowing through a unit width of the aquifer for a unit change in head. It is a measure of an aquifer's ability to transmit groundwater. In **Figure 3.7-7**, N-Aquifer transmissivities are fairly similar (same order of magnitude), indicating that the aquifer is fairly uniform within the leasehold.

On the lease areas, PWCC monitors water levels in the N-Aquifer supply wells and associated observation wells. Historically there have been eight supply wells, numbered NAV2 through NAV9 (**Appendix WR-5, Figure WR-5.3**) and observation wells NAV3OBS and NAV6OBS. After cessation of coal slurry pipeline operations at the former Black Mesa Mine at the end of 2005, water levels in NAV3OBS rose from a depth of 1,183.7 feet bgs to 978.4 feet bgs by the end of 2011. This represents a recovery of 205.3 feet from the maximum drawdown of 453.7 feet, or about 42 percent (OSMRE 2012). Recent static water levels in NAV3OBS are about 985 feet bgs (PWCC 2014). Similarly, at PWCC monitoring well NAV6OBS, water levels rose about 136.0 feet from the maximum drawdown of 433.5 feet bgs, a recovery of about 31 percent as of the end of 2011 (OSMRE 2012). Recent static water levels in the NAV6 vicinity are about 1,181 feet bgs (PWCC 2014).

Although water level recovery is occurring at NAV6OBS, the response is not as steady as at NAV3OBS. Observation well NAV6OBS is in stronger hydrologic connection to historical PWCC production well NAV5 (OSMRE 2012), (which has recently been abandoned). Differences in pumping history before and after the end of 2005 also affect the water levels. Prior to 2006, NAV3 was pumped at a higher rate than NAV6; after 2005, NAV6 was pumped at a higher rate than NAV3.

For PWCC NAV wells and associated observation wells in 2013, N-Aquifer static water level depths within the coal lease areas ranged from 730 feet bgs at NAV4, to 1,201 feet bgs at NAV6. The elevation (not depth) of the top of the N-Aquifer ranges from 3,914 feet at NAV7 to 4,279 feet at NAV6/6OBS. The amount of artesian head (height of water above the top of the N-Aquifer) was approximately 1,256 feet up through 2005 (using data from NAV wells 3, 4, 5, 6, and 9). Since coal slurry pipeline operations and related pumping withdrawals ceased in 2005, artesian head has increased an average of approximately 233 feet for the production wells, 162 feet for observation well NAV3OBS, and approximately160 feet for observation well NAV6OBS.

Through 2014, there remains at least 1,195 to 1,595 feet of artesian head (an average of 1,468 feet) above the N-Aquifer at the PWCC wells (PWCC 2012 et seq.). Substantial artesian head also occurs elsewhere within the confined N-Aquifer, as indicated in **Appendix WR-8, Figures WR-8.9** through **WR-8.12**, and decreases toward the confine/unconfined boundary. In wells that are outside the confined zone, water levels are at or below the top of the N-Aquifer. This also is reflected in the **Appendix WR-8** figures.



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 3.7-7
N-Aquifer Transmissivities

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N-Aquifer Water Use

All mine withdrawals are from the confined portion of the aquifer (USGS 2015). Historical mine withdrawals are provided in **Appendix WR-7, Table WR-7.1**. Maximum N-Aquifer withdrawals for the mine were 4,740 acre-feet in 1982. More recently in 2005, N-Aquifer water use at the mine was 4,480 acre-feet per year. That declined substantially in 2006 (to 1,200 acre-feet per year) with the end of coal slurry pipeline operations that supplied the Mojave Power Plant. The mean annual pumping for 2006 through 2012 was about 1,273 acre-feet per year. Recent pumping from all mine wells has varied annually, and has ranged from about 1,200 to 1,600 acre-feet per year. For example, mine withdrawals were 1,370 acre-feet for Calendar Year 2012, and 1,171 acre-feet in Calendar Year 2010 (Macy and Truini 2016; Macy et al. 2012). More recent withdrawals reported by PWCC were 1,464 acre-feet in 2013, and 1,584 acre-feet in 2014. The variations are due to dust suppression uses, well maintenance and sampling needs, and other factors. In 2014, PWCC operated eight water supply wells on its leasehold. These wells and their 2014 production volumes are given in **Table 3.7-8**. PWCC has recently plugged Well NAV 5 and shifted its production to other NAV wells.

Table 3.7-8 PWCC 2014 Well Withdrawals

Well	acre-feet
NAV2	897.5
NAV3	16.3
NAV4	38.9
NAV5	81.1
NAV6	244.9
NAV7	46.4
NAV8	225.8
NAV9	33.0
Total	1,583.9

Future mine withdrawals are projected to average about 1,200 acre-feet per year through 2044, decline to 500 acre-feet per year through 2047 and then continue at 100 acre-feet per year from 2048 through 2057 before ceasing altogether. Water uses at the mine include domestic supply and sanitation, equipment and coal-processing operations and maintenance, dust suppression (as required by federal regulations), and providing water to nearby tribal residents. The PWCC leases and approved Surface Mining Control and Reclamation Act permit specify monitoring and maintenance of the N-Aquifer wells (OSMRE 2011a).

Recent estimates of N-Aquifer pumping by 27 tribal centers in the study area indicate that from 2008 through 2012, between 2,500 and 3,100 acre-feet per year were withdrawn for community uses (Macy 2014). Historic PWCC and community pumping volumes are tabulated in **Appendix WR-7, Table WR-7.1**.

N-Aquifer Water Quality

Recent water quality data for individual N-Aquifer wells at the Kayenta Mine are summarized in **Appendix WR-7, Tables WR-7.2** through **WR-7.10**. Recent (2010-2014) water quality summaries for the N-Aquifer wells on the coal leasehold indicate TDS concentrations across all the N-Aquifer wells in the coal lease area ranged from 80 to 315 mg/L, with average and median values of 151 and 130 mg/L, respectively. Sulfate concentrations ranged from about 1.4 to 127 mg/L, with average and median values of 22.4 and 8.7 mg/L, respectively (**Appendix WR-7, Table WR-7.2**). These concentrations are substantially lower than D-Aquifer values tabulated below. Total cadmium was only detected in 1 out of 74 sample analyses, and that value (6 µg/L at NAV7 in January 2013) was 1 µg/L above the drinking water criterion. This result was likely a laboratory error; analysis of a subsequent 2013 sample indicated a total cadmium concentration below the detection level of 0.1 µg/L (PWCC 2014). Total lead was below detection levels in 66 of 76 samples (87 percent) but did exceed drinking water criteria (15 µg/L expressed as total concentration) in one sample at NAV2. All other constituents were within drinking water criteria except pH. Historically all of the NAV wells except NAV8 have produced water with typical pH values greater than the recommended secondary drinking water maximum (8.5 standard units). Similar pH conditions also occur at other supply wells in the study region.

Areas of potential D-Aquifer leakage to the N-Aquifer across the Carmel Formation are depicted in **Appendix WR-6, Figure WR-6.4**. They occur well south of the leasehold (Truini and Macy 2006). The regional continuity of the Carmel Formation is depicted in **Appendix WR-6, Figure WR-6.5**. The formation thins southwest of Pinon, and generally thickens near the coal lease area. In combination with NAV well water quality monitoring results (**Appendix WR-7**), it can be concluded that D-Aquifer communication with the N-Aquifer in the leasehold has resulted in negligible water quality effects in the PWCC NAV wells and has not impaired N-Aquifer water quality. Little or no changes have occurred to N-Aquifer water quality since the onset of mine-related pumping, and the water is well within applicable water quality standards.

The potential for induced leakage from the D-Aquifer due to groundwater pumping in the N-Aquifer is less in the area where the N-Aquifer is confined by the Carmel Formation than in areas where the Carmel Formation is thin or sandy. The thickness and lithology of the Carmel Formation are factors influencing groundwater leakage between the aquifers. Areas where the Carmel Formation is less than 120 feet thick coincide with areas where water from the overlying D-Aquifer has historically (over thousands of years) mixed with underlying N-Aquifer water (Truini and Longsworth 2003; Truini and Macy 2006). The Carmel Formation is thicker than that in the lease area, ranging from 140 to 170 feet thick in NAV well drilling logs. Based on historical and recent N-Aquifer water quality results from the coal lease area, water quality effects from the D-Aquifer leakage are negligible in the PWCC NAV wells.

3.7.3.3.1.2 D-Aquifer

The D-Aquifer includes the Dakota Sandstone, the water-bearing portions of the Morrison Formation, and the Cow Springs Sandstone. In the Kayenta Mine leasehold area, the thickness is approximately 1,000 feet. The D-Aquifer is overlain by the Mancos Shale and is confined within the coal lease areas, as well as over most of the cumulative study area (Arizona Department of Water Resources 1989).

Groundwater modeling for PWCC has indicated that the greatest change in D-Aquifer water levels are within the PWCC leasehold, where incidental drawdown due to mine withdrawals has lowered water levels by about 150 feet (Tetra Tech 2015a). Outside the leasehold no significant change in groundwater flow direction has occurred due to this drawdown.

D-Aquifer Hydraulic Parameters and Well Yields

Regionally, average D-Aquifer specific yield was estimated to be 0.015 based upon core samples adjusted to compensate for the non-water-bearing units included in the thickness (Cooley et al. 1969). The D-Aquifer is confined beneath the Kayenta Mine, and the calibrated specific storage coefficient used in the PWCC groundwater flow model is 3×10^{-7} per foot. Based on regional specific capacity data from 45 outlying wells reportedly screened in one or more D-Aquifer units, horizontal hydraulic conductivity ranges from 0.004 to 2 feet/day (HDR Engineering, Inc. 2003). These hydraulic conductivity values are summarized in **Table 3.7-9**.

Table 3.7-9 D-Aquifer Hydraulic Conductivity

Parameter	Values (feet/day)
No. of Tests	45
Average	0.27
Median	0.11
Minimum	0.004
Maximum	2.04

Source: HDR Engineering, Inc. 2003.

These values are indicative of the low permeability nature of the formations comprising the D-Aquifer system. As discussed above for the N-Aquifer, additional information about the D-Aquifer is presented in **Appendix WR-6**. Potential areas of D-Aquifer leakage to the N-Aquifer are indicated in **Appendix WR-6, Figure WR-6.4** from USGS investigations. Also based on USGS investigations, the continuity of the Carmel Formation (which isolates the D-Aquifer from the N-Aquifer under the coal leasehold) is depicted in **Appendix WR-6, Figure WR-6.5**.

Well yields from the D-Aquifer are not well documented. Most wells are powered by windmills and are used for livestock watering purposes with withdrawals of less than 0.5 acre-feet per year. Some community wells may produce up to 100 gallons per minute (gpm) (Tetra Tech 2011).

<u>D-Aquifer Water Use</u>

Water from wells in the D-Aquifer on Black Mesa primarily is used for livestock watering, with some incidental industrial use by PWCC on the Kayenta Mine leasehold and also some community uses. Three of the eight PWCC water supply wells were perforated in both the D- and N-Aquifers. Historically (2005 and before) PWCC estimated that up 130 acre-feet per year was extracted from the D-Aquifer by these wells, out of roughly 4,500 acre-feet per year that were pumped by PWCC in 2005 and before. One well (NAV 5) has been abandoned, leaving two wells (NAV 4 and 7) perforated in the D-Aquifer. These also are being modified to reduce influence from the D-Aquifer. As noted previously, PWCC is presently modifying the proposed KMC water supply system to eliminate withdrawals from the D-Aquifer.

Based on USGS information for screened or open intervals in monitored wells in the study area (Macy and Unema 2014), several other locations are open to the D-Aquifer (or other zones) and likely withdraw from them as well as the N-Aquifer. These include Forest Lake NTUA1 (4T-523), Kykotsmovi PM1, Marsh Pass (8T-522), Howell Mesa (3K-311), and Black Mesa Observation Well 1 (8T-537).

<u>D-Aquifer Water Quality</u>

Groundwater quality in the D-Aquifer is marginal to unsuitable for domestic use, although it may be acceptable for other uses. TDS concentrations range from 190 to 4,410 mg/L, generally exceeding the recommended limit of 500 mg/L for drinking water. Fluoride concentrations range from 0.2 to 9.0 mg/L and often exceed the maximum contaminant level concentration of 4 mg/L. Water quality improves slightly in the southern portion of the aquifer (Arizona Department of Water Resources 1989).

Water quality data for D-Aquifer wells are limited to 43 wells with sampling occurring between 1950 and 1999 (USGS 2015). Locations of the wells are shown on **Figure 3.7-8**. Data are summarized in **Table 3.7-10**.

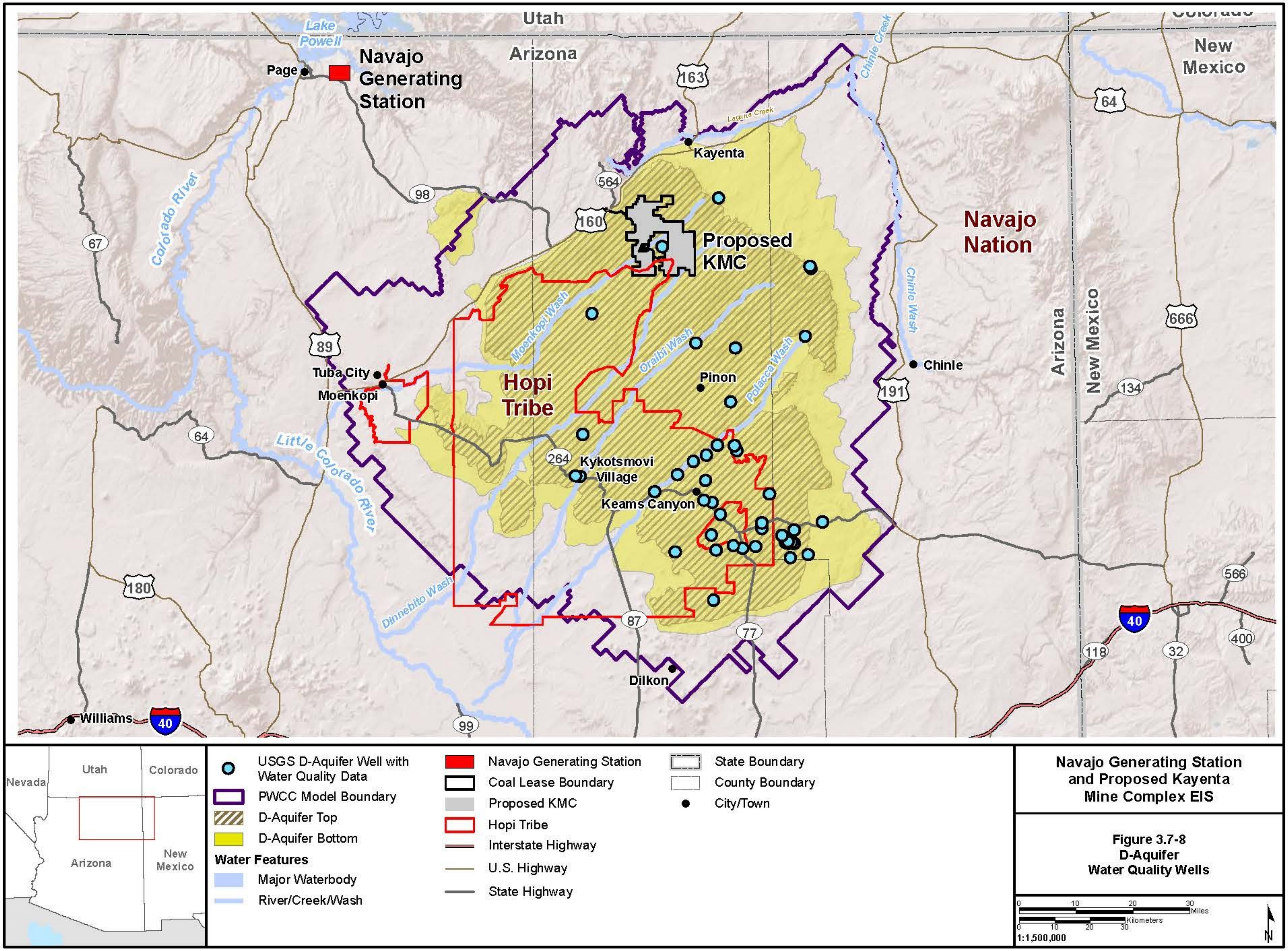

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Figure 3.7-8
D-Aquifer
Water Quality Wells

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Table 3.7-10 D-Aquifer Water Quality

Parameter[1]	Sodium (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Arsenic (mg/L)	TDS (mg/L)
No. of samples	21	43	42	4	7
Average	198	57	376	0	902
Maximum	650	260	1,700	0.009	2,120
Minimum	5.7	4.4	9	0.001	148
Drinking Water Maximum Contaminant Levels	None listed	250	250	0.01	500

[1] Drinking water standards are further explained in tables presented in **Appendix WR-7**.

Source: USGS 2015.

There is a regional concern about the exchange of groundwater from the D-Aquifer to the N-Aquifer, and consequential adverse effects on N-Aquifer water quality. Groundwater leakage from the D-Aquifer through the Carmel Formation to the N-Aquifer has been occurring naturally for thousands of years (Truini and Macy 2006). **Appendix WR-6, Figures WR-6.4** and **WR-6.5** indicate the areas of natural anticipated leakage between the aquifers, and the continuity of the intervening Carmel Formation across the project vicinity, respectively. PWCC is currently rehabilitating selected N-Aquifer (“NAV”) wells within the coal leaseholds to eliminate contributions from the D-Aquifer. Flow between the aquifers along PWCC wellbores will be eliminated prior to 2020. In the leasehold area, little or no effects on N-Aquifer water quality have resulted from mine-related pumping.

3.7.3.3.1.3 D- and N-Aquifer Springs

The USGS undertook a study to identify and characterize springs identified by various methods (Leake et al. 2016). A total of 104 springs characterized as “likely” were identified as emanating from D- and N-Aquifer stratigraphic units. With the exception of the four USGS monitored springs, individual sites were not visited and no flow data are available. To facilitate the discussion of impacts of proposed mine-related pumping on springs and seeps, these features were grouped into major areas (“A” through “J”) based on their geographic and hydrogeologic similarity. Further discussion of this is presented in the Environmental Consequences section. Additional spring information is presented in **Appendix WR-10.**

3.7.3.3.1.4 Wepo Formation

The Wepo Formation is the geologic unit at or near the land surface over much of Black Mesa. It crops out in the northern portions of the mesa, where it is exposed over approximately 1,270 square miles (Peirce et al. 1970). It consists of several bedrock types, dominantly including interbedded shale, siltstone, sandstone and coal that erode to form steep slopes (Nations et al. 2000). The upper Wepo Formation is the source of coal mined by PWCC. The formation contains the highest quality coal on Black Mesa as well as the largest minable reserves (Peirce et al. 1970).

The top of Black Mesa is an erosional surface, and the thickness of the Wepo Formation in a particular locale depends on geologic structure and the extent of downcutting by streams such as Moenkopi, Dinnebito, and Oraibi Wash. Additional geologic characteristics of the Wepo Formation are discussed in **Appendix WR-5**. The formation consists of interbedded sandstones, mudstones and claystones, coal, and carbonaceous shales. These sedimentary rocks were formed in several depositional environments as described in the Appendix. Rock layers are discontinuous, and generally have limited spatial extent. The thickest and most continuous coal seams are in the upper half of the formation, in the northern part of the mesa where the upper half has not been completely eroded away. Individual coal seams may extend laterally for hundreds or thousands of feet, but eventually thin out. Other seams usually occur within a few feet vertically. This is generally depicted in **Appendix WR-5, Figures WR-5.1** and **WR-5.2**.

A combination of erosion or naturally burned coal seams limits the mineable reserves to detached, irregular areas or “islands” (Peirce et al. 1970). Northeastward across Black Mesa, the Wepo Formation thins and tongues into the overlying Yale Point Sandstone and into the underlying Toreva Formation (Repenning and Page 1956).

Arizona Department of Water Resources (2008) describes this unit as mainly unconfined, with perched water zones overlying relatively low-permeability coal, siltstones and mudstones. It has variable water levels, and is likely to have complex flow directions due to the occurrence of perched water-bearing zones (Arizona Department of Water Resources 2008). PWCC investigations indicate that confined conditions are more common in the leasehold. Some variations in Wepo Aquifer hydraulic characteristics within the leasehold are indicated on **Figure 3.7-9**.

These variations within the Wepo Formation have been investigated through aquifer tests by PWCC. Transmissivity is a measure of how much water can be transmitted horizontally through a saturated zone, for example, to a pumping well. The large range in transmissivities, and thus aquifer characteristics, within the Wepo Formation can be seen on **Figure 3.7-9** (PWCC 2012 et seq.). This further confirms the nature of the Wepo Formation as a highly variable aquifer. For example, transmissivity values within 2 or 3 miles range from 0.25 gallons per day (gpd) per foot at Site 44 near the center of the leasehold, to 7 gpd per foot at Site 53, to 132 gpd per foot at Site 43. Similarly, at Site 62, the transmissivity is 0.1 gpd per foot, but 2 miles away it is 204 gpd per foot at Site 63. In contrast to N-Aquifer conditions (**Figure 3.7-7**), the Wepo values indicate a high degree of variation in hydraulic characteristics within fairly short distances. This corresponds to the isolated, perched nature of water-bearing zones in the Wepo Formation, and to differences in their geologic characteristics.

Since most of the transmissivity values are fairly low [less than 100 gpd per foot, with a median of 40 gpd per foot (OSMRE 2011b)], the water-yielding nature of the Wepo Formation is limited in the mine area. Conceptually this is further supported by the discontinuous extents of geologic layers represented in **Figure 3.7-10**. On **Figure 3.7-10**, Facies A and C zones consist of more porous sandstones, Facies D zones are isolating deposits of claystone and mudstone, and Facies E is coal and carbonaceous shale. Additional geologic discussion is presented in **Appendix WR-5**. The depositional framework consists of sheets or ribbons of sandstones that are encased in an interbedded sequence of claystone, mudstone, and coal (Carr 1991). Laterally, the Facies A sandstones range from a few feet up to about three or four miles in extent (Carr 1991). Aquifer continuity is restricted by the surrounding low-permeability Facies D materials. The most laterally continuous zones are the coals and carbonaceous shales (Facies E). These form beds of less than a foot up to about 15 feet thick, and extend from less than 0.6 to over 8 miles laterally. The coal beds typically pinch out, grade into carbonaceous shale, or end abruptly at sandstone deposits (Facies A) (Carr 1990). They do not form significant aquifer zones. Based on transmissivity and geologic characteristics, the Wepo Formation forms isolated water-bearing zones within the coal leasehold. These provide little or no hydrologic connection to different locations beyond the leasehold. The formation is an inconsistent source of water to wells, and springflows vary with local conditions in source areas bounded by canyons and washes.

Water levels in individual Wepo Formation monitoring wells (WEPO series wells) have been recorded over time by PWCC. These locations are depicted in **Appendix WR-5**, **Figure WR-5.3**. **Appendix WR-5, Tables WR-5.1** and **WR-5.2** indicate changes in water levels within these wells over time including recent years. Many of the water levels have been rising slightly (levels shallower than in previous years, however most of the wells have fairly small fluctuations, on the order of 1 foot or less since 2005 (**Appendix WR-5, Table WR-5.1**). Over time, there are several primary reasons for water level fluctuations in Wepo Formation monitoring wells. These mainly include: recharge associated with significant (and sometimes highly localized) precipitation events; extended dry periods; water quality sampling; and drainage to mine pits. Historically, other causes such as aquifer testing and residual drilling effects also contributed to water level variations in Wepo wells (PWCC 2012 et seq.).

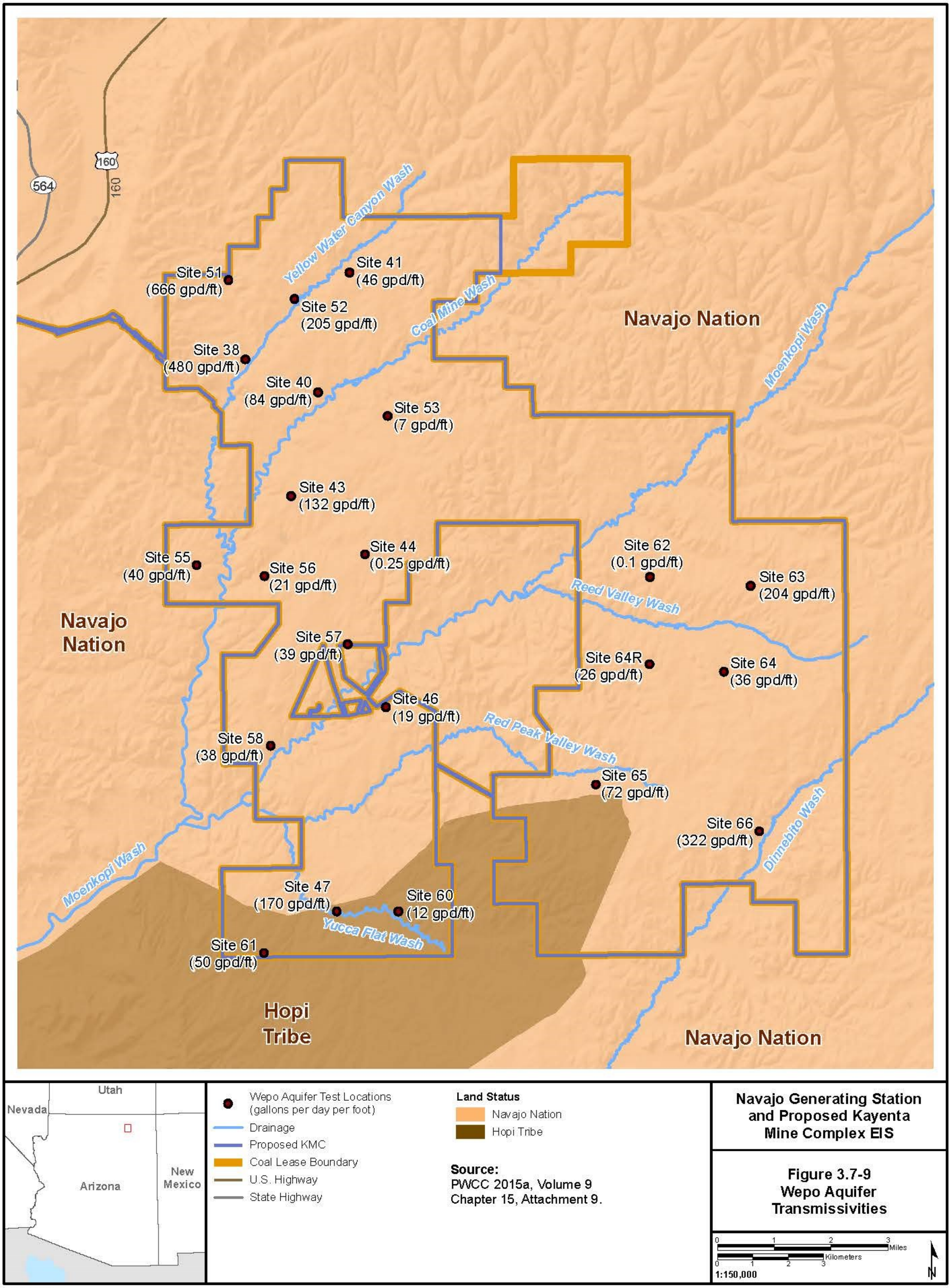
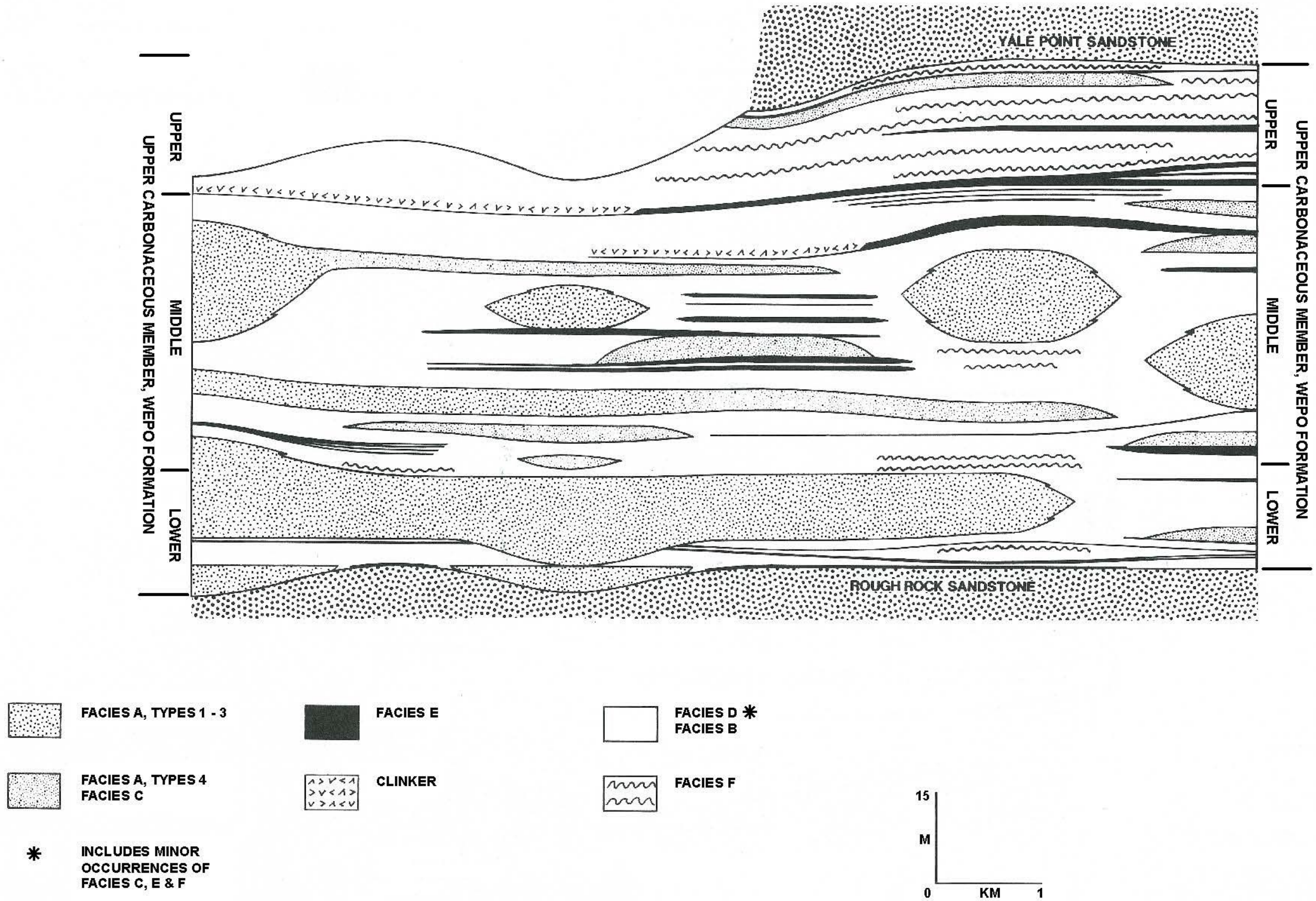


Figure 3.7-9
Wepo Aquifer Transmissivities



Source: Carr 1990

*Further explanation and details are provided in Appendix WR-5

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Figure 3.7-10
General Nature of the Wepo Formation

Although surface water quality standards for livestock watering do not apply to groundwater in the Wepo Formation or any other aquifer, sampling results have been compared to surface water standards simply as a source for comparison. None of the Wepo monitoring wells indicated exceedances of established tribal surface water quality criteria for livestock watering. General water quality classifications range from mixed sulfate to sodium bicarbonate types. A detailed discussion of water quality in the Wepo Formation is presented in **Appendix WR-5** and summarized in **Tables WR-5.3** through **WR-5.12**. Dissolved trace elements are generally at low concentrations or are undetected throughout the leasehold. Sulfate and bicarbonate concentrations vary, and sodium is typically a dominant constituent. The median background bicarbonate concentration is about 600 mg/L, and the median background sulfate concentration is about 170 mg/L. Higher sulfate and lower bicarbonate concentrations occur within smaller locales in the coal leasehold. The median background TDS concentration is about 860 mg/L, but higher values occur in some parts of the leasehold. Further information is presented in **Appendix WR-5**.

3.7.3.3.1.5 Alluvial Aquifer (Unconsolidated Stream Channel Sediments)

Sediment has been deposited within the channel of all of the major drainages on Black Mesa. These sediments consist of sand and gravel, silts, and clays that are initially transported from uplands by rainfall and runoff. They are then deposited, stored, and further transported through the stream networks by rising and falling flows, and known as stream-laid alluvial deposits. Shallow groundwater occurs within these deposits, forming relatively narrow, linear alluvial aquifers along the stream channels. These water-bearing zones interact with surface water flows, springs, and underlying bedrock aquifers. The alluvial aquifer is a link between streamflows and groundwater from underlying water-bearing bedrock. Water absorbed and released by the alluvium supports riparian vegetation and corresponding aquatic and wildlife habitats.

Bedrock that underlies the alluvium at upper elevations on Black Mesa consists mainly of rock units within the Wepo Formation. At progressively lower elevations toward the valley floors at Tuba City and elsewhere, the alluvium interacts with the Toreva Formation, the D-Aquifer, and the N-Aquifer based on their nearness to the land surface along streams. Where the N-Aquifer is unconfined (outside the confined zone, **Figure 3.7-3**), there is direct hydrologic communication between that bedrock aquifer and alluvial channel deposits. The alluvium is recharged by surface water infiltration and from groundwater flowing from saturated bedrock aquifer zones on the mesa and out on the valley floor. Within the coal permit areas, recharge to the alluvium from truncated saturated areas of the Wepo Formation help maintain the alluvial water levels during extended dry periods (OSMRE 2011a).

The alluvial deposits vary from coarse (gravel and sand) to fine (silts and clays) depending on the geologic nature of the surrounding landscape and how far the sediments are transported. Where the N-Aquifer is unconfined, alluvial textures are typically coarser, dominated by sands and gravels from the Navajo Formation and other coarse-textured bedrock. In the coal lease areas at higher elevations on the mesa, Wepo Formation characteristics create a broad variety of these alluvial grain-size distributions (or "textures"). On Black Mesa, all of the major washes in and near the coal leases (Yazzie Wash, Coal Mine Wash, Moenkopi Wash, Dinnebito Wash, Reed Valley Wash, Red Peak Valley Wash) have alluvial deposits along their channels. These deposits vary in their location and extent along the streams, in their thickness above bedrock, and in their textural, chemical, and hydrologic characteristics.

PWCC has constructed alluvial aquifer wells to monitor corresponding water levels and water quality data in accordance with regulatory requirements. Data have been collected and reported by PWCC since the 1980s. **Appendix WR-4**, **Figure WR-4.1** indicates locations of alluvial monitoring wells. During 1980, PWCC conducted detailed investigations (in accordance with Surface Mining Control and Reclamation Act regulations) to determine the potential occurrence of alluvial valley floors. Although alluvial valley floors were determined not to exist on or immediately adjacent to the Kayenta Mine, these studies also provided information about the thickness and saturation of alluvium through the use of seismic refraction surveys (OSMRE 2011a).

The uppermost headwater branches of all washes and tributaries contain little or no alluvial groundwater. In general, saturated thicknesses ranged from 3 to 34 feet in larger deposits at lower positions in canyons and valleys. The thinnest saturated alluvial thicknesses occurred in the upper reaches of the major washes, and the thickest occurred in the lower reaches (OSMRE 2011a). The greatest saturated cross-sectional areas were determined to be along lower Coal Mine Wash, lower Moenkopi Wash, and lower Dinnebito Wash (OSMRE 2011a). Records taken during alluvial well construction indicates that the deposits vary in both width and depth along any given wash, as well as from one wash to another. The sediment accumulations consist of poorly sorted materials (with mixed particles ranging in size from clays to cobbles), and also as thin beds of more sorted materials. In turn, these material variations influence the hydraulic properties of the alluvium, creating variable groundwater storage and movement properties from one location to another.

Transmissivity tests of alluvial aquifers were conducted in the alluvial well bores or in pits dug in the deposits (PWCC 2012 et seq.).These investigations measured the amount of water that can be transmitted horizontally within the saturated alluvial zone, for example to a pumping well. The results of these are indicated on **Figure 3.7-11**. In addition to the geologic variation indicated in well construction records, variations in hydraulic conditions in channel alluvium are evident from the different test values obtained along the washes. These results can vary an order of magnitude or more within the same wash (OSMRE 2011a). For example, alluvial transmissivity values along Yellow Water Canyon Wash in the northwest part of the leasehold vary from 37 gpd per foot at Site 72, to 3,508 gpd per foot at Site 75 about 1 mile downstream. Similar variations can be seen along Coal Mine Wash, Moenkopi Wash, and elsewhere in the leasehold. This attests to the variable nature of alluvial aquifer zones on the leasehold. In particular, it can be seen from **Figure 3.7-11** that the transmissivity of the alluvial deposits does not necessarily increase downstream.

Water level changes in the alluvium result from temporal changes in evaporation; variable uptake and transpiration by vegetation along the washes; changing runoff conditions and resulting changes in streamflow; and from contributions at springs and connected bedrock aquifers. These are primarily natural variations that occur throughout the region. In the coal lease areas, seepage from ponds or drawdown near mined areas also affect alluvial water levels. PWCC routinely monitors water levels in the alluvial monitoring wells. Recent data indicate water level changes in these wells typically rise or fall between less than 1 foot to about 3 feet. A few wells have greater fluctuations, but most changes are less than about 1.5 feet. The direction of change (either rising or falling) changes from year-to-year. For example, water levels generally fell in 2009 compared to 2008, but generally rose in 2013 compared to 2012 (**Appendix WR-4**, **Table WR-4.1**). Climatic variations (temperature, rainfall) and related evapotranspiration rates contribute to these effects. Further discussion of vegetation is presented in EIS Section 3.8, and climatic factors are discussed in EIS Sections 3.1 and 3.2.

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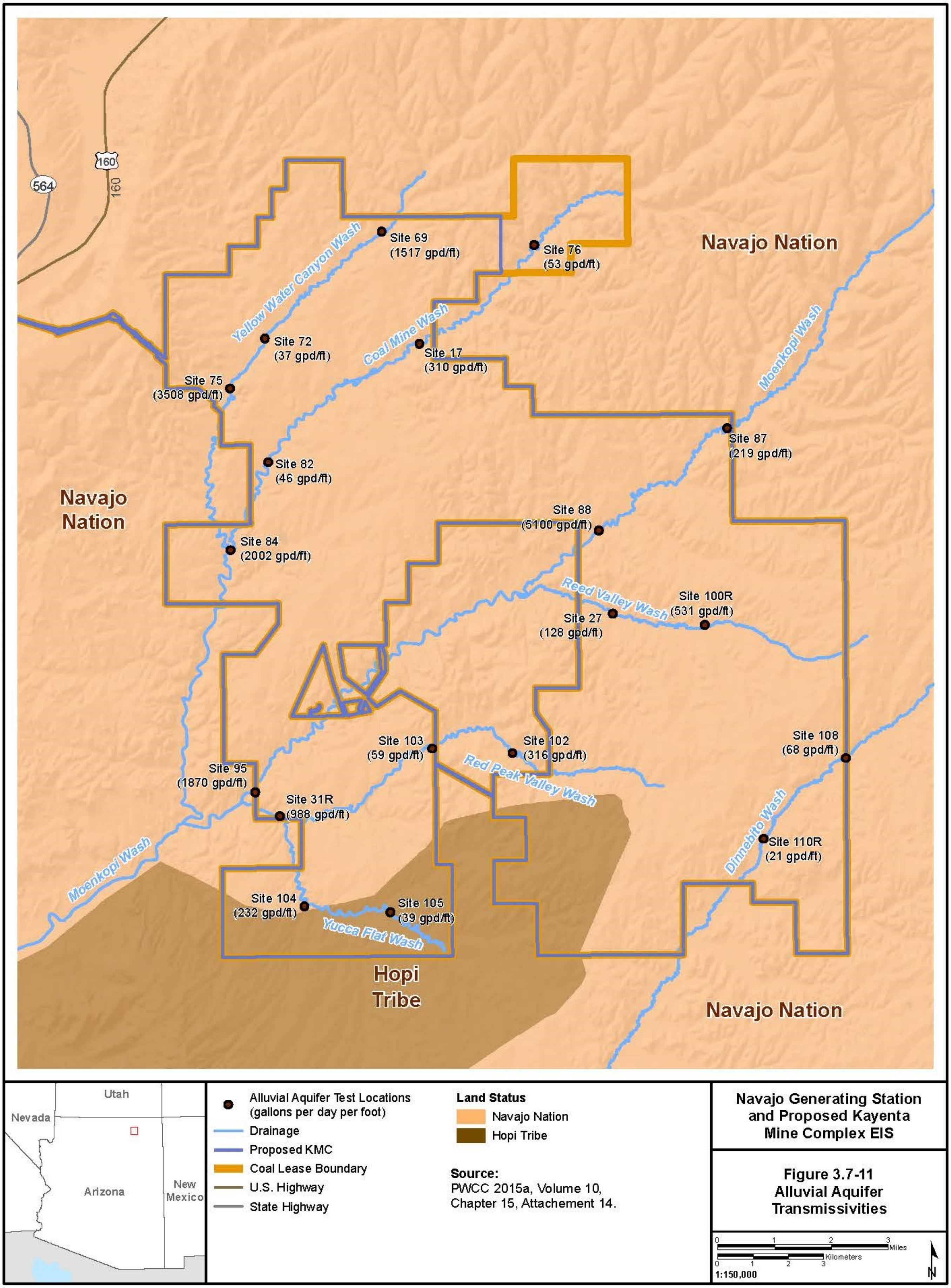

Source:
PWCC 2015a, Volume 10, Chapter 15, Attachement 14.

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Figure 3.7-11 Alluvial Aquifer Transmissivities

7/20/2016

Although surface water quality standard for livestock watering do not apply to groundwater in the alluvium or any other aquifer, sampling results have been compared to surface water standards simply as a source for comparison. Based on this, no exceedances of livestock watering standards established for surface water occur in recent alluvial groundwater data. See **Table 3.7-11** for a general summary and **Appendix WR-4**, **Tables WR-4.1** through **WR-4.7** for more detail. Along Moenkopi Wash upstream of the mine areas, recent (2010-2014) background TDS concentrations ranged from 2,400 to 9,900 mg/L, and sulfate values ranged from 1,470 to 6,300 mg/L. Upstream of mining along Dinnebito Wash, recent TDS concentrations in alluvial wells ranged from 2,550 to 3,160 mg/L, and sulfate values ranged from 4,380 to 4,990 mg/L. These fairly high values reflect undisturbed conditions for the higher topography and geologic setting of Black Mesa. Broadly similar elevated TDS concentrations are reflected in recent data downstream along Yellow Water Canyon, Reed Valley Wash, and Dinnebito Wash through the mine area. For sulfate, median values along Yellow Water Canyon Wash, Moenkopi Wash, Red Peak Valley Wash and Dinnebito Wash range from about 2,000 to 2,500 mg/L. A broader sulfate range occurs along Coal Mine Wash and Reed Valley Wash, with median values of 3,400 and about 3,800 mg/L, respectively. In summary, water quality in the narrow alluvial deposits upstream of and through the coal leasehold reflects fairly high TDS and sulfate contents, but trace element concentrations are low or undetected.

Table 3.7-11 General Alluvial Groundwater Quality Characteristics

Alluvial Drainage at the Kayenta Mine	General Groundwater Quality Type
Yellow Water Canyon Wash	Mixed sulfate
Coal Mine Wash	Mixed sulfate
Moenkopi Wash	Variable: mixed bicarbonate to mixed sulfate
Reed Valley Wash	Mixed sulfate
Red Peak – Yucca Flat – Sagebrush washes	Variable: calcium bicarbonate to mixed sulfate
Dinnebito Wash	Mixed sulfate or calcium sulfate

Source of monitoring data: PWCC 2012 et seq..

3.7.3.3.2 Springs and Seeps at the Proposed KMC

3.7.3.3.2.1 Spring Flow Quantities

Flows from monitored springs are summarized in **Appendix WR-3, Table WR-3.1**, and their locations are depicted on **Figure WR-3.1**. Long-term monitoring, which includes recent data, indicates typical flows of less than 1 gpm at most monitored spring locations. Monitoring data indicate that flows from most springs cease for extended periods. Larger flows and durations occur at Site Native Spring 561 along lower Red Peak Valley Wash, at Native Spring 563 nearby, and at Site Native Spring 92 on the northeast smaller tributary to Moenkopi Wash. These are supported by seepage from upstream ponds. Seasonal flows from springs often peak from late February through early April, and sometimes reach another peak in September or October. Maximum flows occasionally occur in the winter (November through January). Extended no-flow periods occur, particularly from late spring to late summer or early fall.

3.7.3.3.2.2 Spring Flow Quality

Water quality from recent (2010 through 2014) spring monitoring is summarized in **Appendix WR-3**, **Tables WR-3.2** through **WR-3.5**. Long-term data are summarized in **Appendix WR-3, Tables WR-3.6** through **WR-3.12**. Water quality from almost all monitored springs have elevated levels of sulfate and TDS, including those sites (such as Native Spring 111 or Native Spring 140) that have not been affected by mining activities. For example, recent sulfate values at Native Spring 111 are approximately 4,000 mg/L, and TDS concentrations there are over 6,000 mg/L. At Native Spring 140, typical long-term (since 1981) sulfate and TDS concentrations are approximately 3,000 mg/L and over 4,500 mg/L, respectively.

One exception to these generally elevated concentrations is Native Spring 91, located along Coal Mine Wash adjacent to the N2 mine area. TDS concentrations in samples from Native Spring 91 range from about 1,360 to 1,430 mg/L, with sulfate concentrations of about 680 to 800 mg/L. These values are relatively low concentrations for monitored springs, and more typical of Wepo Formation wells near mining.

3.7.3.3.2.3 Seeps

Seeps also occur in scattered locations in the coal lease areas and are monitored through the seep management program. This is conducted by PWCC in response to USEPA water quality requirements through NPDES permitting. These seeps are associated with sedimentation structures upstream. Water quality of the seeps is influenced by the geologic strata in the vicinity of the pond, and by the earthen materials used to form the embankment. Seep drainage quickly dissipates into the alluvium downstream of the ponds, and does not influence more distant resources.

Documentation in associated reports indicates that USEPA determined that the following designated uses and associated criteria from the applicable Hopi Tribe and/or Navajo Nation surface water quality standards for evaluating seep water quality (PWCC 2012 et seq.):

- Agricultural Livestock (Livestock Watering);
- Partial Body Contact (Secondary Human Contact); and
- Ephemeral Warm Water Aquatic (Aquatic and Wildlife Habitat).

Seeps generally flow at smaller rates than springs and typically form as wet spots lacking a free-water surface. Their occurrence at the Kayenta Mine is managed by inspection, pond dewatering and water transfers between ponds, fencing to restrict livestock access, pond removal, and other actions. A formal seep management planning and reporting program is active at the Kayenta Mine, as conducted by PWCC and coordinated with, and reported to USEPA and OSMRE. Between 10 and 15 seeps have been monitored each year since 1999 (Tinger 2015). Historically, 21 sites have been monitored in total, with seeps occurring at 20 sites. USEPA has established a set of "risk levels" and defined them as described below (Tinger 2015):

- Level 1: "Generally contains very low flows, few instances of observed seeps. If seep observed, seep meets water quality standards or had one sample slightly above water quality standards."
- Level 2: "Generally contains medium flows, but seeps detected at higher frequencies. Multiple samples may be above water quality standards, but samples above water quality standards are only slightly above water quality standards. No samples significantly above water quality standards. No bioaccumulative toxic pollutant above water quality standards."
- Level 3: "May be one or a combination of high flows, high occurrences of seeps, multiple samples above water quality standards, or any sample significantly above water quality standards. Any sample of bioaccumulative toxic pollutant above water quality standards is a Level 3 risk."

Based on these USEPA-defined categories and PWCC monitoring, eight seep locations at the Kayenta Mine have been categorized during the program as Level 1, six as Level 2, and five as Level 3. Water quality standard are met at 2 locations, and are not met at 18 (Tinger 2015). Sulfate, aluminum, and TDS are the constituents typically exceeding applicable water quality standard. This is generally similar to conditions at springs described above.

3.7.3.3.3 Surface Water Features and Management at the Proposed KMC

The coal leasehold and surrounding area are described in Chapter 1.0 and depicted on **Figure 1-5**. Surface water resources on Black Mesa are dominated by sandy ephemeral washes, widely scattered springs, and constructed ponds. Stream segments are intermittent or perennial in some isolated locations due to contributions from springs and shallow aquifers. Springs are scattered throughout Black Mesa, particularly where erosion has cut cliffs or canyons across aquifer zones. In and near the coal leasehold (and elsewhere at the higher mesa elevations), these springs are mainly supplied by the Wepo or Toreva formations. They are geologically separated from those with D-Aquifer or N-Aquifer sources. Spring inventories have been conducted on the mesa and the N-Aquifer study area by the USGS and others. Recent spring inventories oriented to N-Aquifer features were conducted by the USGS expressly for the EIS. Further detail on this work is presented in **Appendix WR-10** (Leake et al. 2016). Major springs and many smaller ones have been located in relation to several aquifer zones as part of EIS data collection. These are discussed in later text sections and corresponding appendices. A number of siltation ponds and impoundments at the Kayenta Mine are incidentally used for stock watering.

3.7.3.3.3.1 Streamflow Quantity

As previously mentioned, major drainages on the mesa include Moenkopi Wash, Dinnebito Wash, Oraibi Wash, Wepo Wash, Polocca Wash, and far to the east, Jeddito Wash (**Figure 3.7-3**). Most of the mine leasehold area is drained by headwater tributaries to Moenkopi Wash. These include Coal Mine Wash, Yellow Water Canyon Wash, Yazzie Wash, Reed Valley Wash, Red Peak Valley Wash, and Sagebrush/Yucca Flat Wash. Dinnebito Wash and its tributary, Resting Cattle Wash, drain the southeastern part of the leasehold (**Figure 3.7-3**). The main channels generally parallel each other to the south and west, following the overall slope and geologic structure of Black Mesa. Major drainages and their tributaries cut canyons into bedrock as they drain to the Little Colorado River.

Measurements at 14 original stream gages established by PWCC indicate quick response to rainfall, often showing hydrographs with two or more “peaks.” This is due to the nature of storm tracks across the highly dissected bedrock-controlled landscape. As a heavy rainfall cell moves across the tributary watersheds and the main branch of a wash, the times when flows reach a downstream measurement point vary according to the rainfall track and time-of-travel through side-channels and channels. For intense storms, the response times to rainfall are short, creating discharges typified by “flashy” rises and rapid declines (PWCC 2012 et seq.). As described in the PAP, multi-peaked hydrographs occur from one-third to two-thirds of the time based on PWCC stream monitoring data, with even greater occurrence in the fall. Similar conditions are shown in USGS monitoring. The original 14 gages were located to provide upstream-of-mining and downstream-of-mining streamflow and water quality information, and to characterize streamflow and runoff from a variety of drainage areas, vegetation, slopes and channel densities, and other watershed variables. Strong correlations between precipitation types (snowmelt, convective, or frontal events) and their resulting runoff hydrographs were able to be determined. In conformance with regulations, the number of stream monitoring locations was subsequently reduced when sufficient and reliable flow and water quality characterizations had been made (OSMRE 2011b).

Recent PWCC data (2009–2013) in **Table 3.7-12** indicate the following wide ranges of peak flows at ongoing monitoring stations on major washes in the lease areas. These locations are depicted in **Appendix WR-1, Figure WR-1.1**. The ranges in flows chiefly result from variations in rainfall and snowmelt, as well as impoundment retention. Additional discussion of surface flows is in **Appendix WR-1**, including USGS monitoring of Coal Mine Wash (**Table WR-1.5**).

Table 3.7-12 Peak Flows at Current PWCC Streamflow Gages

PWCC Streamflow Gage	General Location	Range in Peak Discharges (cfs)	Range in Flow Durations (hours)	Annual Site Runoff (acre-feet)
SW25	Coal Mine Wash near mouth	0.1 to 1,509	1.7 to 67	19.3 to 1,131
SW26	Moenkopi Wash, just above Red Peak Valley Wash	1 to 5,508	0.23 to 76.5	60.3 to 4,173
SW34 [1]	Dinnebito Wash at south edge of lease area	2.24 to 1,110	4.24 to 45	166 to 674
SW155	Red Peak Valley Wash near mouth, at Moenkopi Wash	0.05 to 8,000	1.3 to 30.2	12.6 to 735.9

[1] Based on records for 2011 through 2013.

cfs = cubic feet per second.

Source: PWCC Annual Reports 2009-2013.

3.7.3.3.3.2 Streamflow Quality

Water quality sampling and data interpretations for the coal lease areas have been carried out by PWCC since beginning in the early 1980s. Recent stream water quality data were obtained from PWCC and are summarized in **Tables WR-1.6** through **WR-1.20** in **Appendix WR-1**. Streamflow monitoring locations are depicted in **Appendix WR-1, Figure WR-1.1**. These data represent current stream water quality characteristics monitored within the lease areas, as well as stream water quality leaving the lease areas. Major channels, including Yellow Water Canyon Wash, Coal Mine Wash, Moenkopi Wash, Red Peak Valley Wash, and Dinnebito Wash are represented. Longer-term water quality characteristics from other PWCC stream monitoring sites are discussed below as part of the cumulative (in time) affected environment description.

In general, stream water quality data from the near-term period 2010 through 2014 (5 years) indicate that streamflow and surface water runoff samples collected at stream monitoring sites established within or just downstream of the coal lease areas have mixed major cation chemistry (calcium, magnesium, and sodium), with sulfate as the dominant anion. TDS concentrations generally range from about 2,000 mg/L to about 5,000 mg/L, but are lower in some cases. The greater concentrations occur during baseflow periods, when streamflows consist of low flows from groundwater contributions. TDS concentrations generally decline during rainfall periods, when larger flow rates and overland runoff feature measurably lower dissolved fractions compared to groundwater baseflow. This can be seen by comparing the median TDS concentration for mixed flows (2,210 mg/L) in **Appendix WR-1, Table WR-1.8** to the median value (5,530 mg/L) for baseflows at the same location in **Appendix WR-1, Table WR-1.9**. The groundwater typically carries greater dissolved concentrations of common constituents (calcium, magnesium, sodium, chloride, sulfate, bicarbonate, and others).

Total Suspended Solids (TSS) concentrations vary widely between low flows to higher, runoff-generated flows. Very high suspended solids values result from the intense storms common to the leasehold and the overall study region (for example, up to 131,000 mg/L in **Appendix WR-1, Table WR-1.8**). Historical measurements (prior to 2010) of TSS in larger runoff events have commonly yielded values in excess of 200,000 mg/L. This constituent reflects the sediment transport conditions common to the study region. Large runoff events (flash floods) typically transport sediment comprised of fine sands, silts and clays along with some organic materials. These fine particles have an affinity for binding trace elements to their surface micro-structure. Samples collected for trace element analysis using the total or total recoverable analytical methods are not filtered before delivery to the analytical laboratory. This contrasts with the filtered samples used for dissolved trace element analysis. Consequently, trace element concentrations in high runoff with very high TSS loads that are analyzed using the total or total recoverable method can be much higher compared to the dissolved concentrations. For example, this effect can be seen by comparing total to dissolved concentrations for arsenic, copper, and lead in **Appendix WR-1, Table WR-1.8**, which represents both sediment-transporting runoff and lower, baseflow conditions. The median total arsenic concentration is 215 µg/L (0.215 mg/L) whereas the median dissolved arsenic concentration is 0.90 µg/L (0.0009 mg/L). The median total copper concentration is 1,285 µg/L (1.28 mg/L) whereas the median dissolved copper concentration is 4.10 µg/L (0.004 mg/L). The median total lead concentration is 895 µg/L (0.895 mg/L) whereas the median dissolved concentration is 0.30 µg/L (0.0003 mg/L). In contrast, **Appendix WR-1, Table WR-1.9**, which represents only low-TSS baseflow at the same site, indicates that neither total nor dissolved concentrations were detected for these trace elements. Very low TSS concentrations are represented in that table.

Water quality standards used for discussion and assessments are based on the more typical uses of surface waters in the study area, on public scoping concerns, and on agency guidance and past documentation from OSMRE (OSMRE 2011b). Related standards are presented in **Appendix WR-1, Tables WR-1.1** through **WR-1.4,** for both the Navajo Nation and the Hopi Tribe. Exceedances of water quality standards do occur for some constituents at some locations, most notably during storm runoff when total concentrations of trace elements are elevated by much greater TSS concentrations. No applicable standards are exceeded in baseflows on middle reaches of Yellow Water Canyon, Coal Mine Wash (Site SW80R), or Moenkopi Wash (Site SW2a) near active mining or reclaimed lands in the middle of the coal lease areas.

In recent (2010 through 2014) data elsewhere, sulfate, TDS, TSS, and total aluminum and iron are the constituents more likely to exceed the most protective water quality criteria or recommended values. Sulfate and TDS exceedances occur in both baseflows and runoff samples, whereas total aluminum and iron exceedances are typical only during runoff. During high runoff events, other constituents such as lead, mercury, selenium, and vanadium commonly have concentrations above the most protective standards as well. For these other constituents, exceedances of the most protective water quality standards generally occur in about 33 to 67 percent of samples from runoff events. Selenium exceedances can be more frequent during high runoff events, for the same elevated TSS reasons described above. These conditions are common to the erosive landscapes typical of watersheds with Cretaceous or younger shales or clays in the region.

Opportunistic livestock watering is perhaps the dominant use of surface water in the coal lease areas. Related standard exceedances are somewhat less frequent for the livestock use, but still occur with arsenic, chromium, copper, lead, and vanadium during large runoff events. Total selenium concentrations that exceed the livestock criterion (50 µg/L) are rare; they only occur in about 17 percent of the runoff samples at Site CG34 on Dinnebito Wash. As mentioned above, of the total trace element concentrations are amplified during runoff because of their chemical association with sediment or organic particulates transported in runoff. These materials are retained in impoundments and siltation ponds downstream of disturbed areas. Large undisturbed areas without such controls still remain along major drainages outside of disturbed lands. It is likely that runoff from these areas is affected by particulates from overland flow or channel re-suspension, and reflect corresponding trace element characteristics.

Based on long-term stream monitoring (**Appendix WR-1, Tables WR-1.17, WR-1.18, WR-1.19,** and **WR-1.20**), water quality results indicate that downstream conditions on the leasehold generally reflect the background water quality of flows monitored upstream of mining activities. On Moenkopi Wash, the upstream dissolved arsenic median concentration is 2.0 µg/L (0.002 mg/L), and downstream it is 1.0 µg/L (0.001 mg/L). The median total selenium concentration is 6.5 µg/L (0.006 mg/L) upstream, and 3.0 µg/L (0.003 mg/L) downstream. The background median TDS concentration is 390 mg/L, and the downstream value is 690 mg/l. The background median sulfate concentration is 150 mg/L, and the median downstream concentration is 383 mg/L. On Dinnebito Wash, the upstream background and the downstream median dissolved arsenic concentrations are similar, at 2.0 and 1.5 µg/L (0.002 and 0.0015 mg/L), respectively. The background median total selenium concentration is 4.5 µg/L (0.0045 mg/L), compared to a downstream median of 3.5 µg/L (0.0035 mg/L). The background median TDS value is 1,239 mg/L upstream, compared to a downstream value of 927 mg/L. The background median sulfate concentration on Dinnebito Wash is 786 mg/L upstream, compared to a downstream median of about 590 mg/L. These results indicate that, while there is some stream water quality variation between drainages and across the leasehold, the downstream conditions generally reflect naturally occurring conditions upstream.

3.7.3.3.3.3 Pond Quantities

Impoundments and sediment ponds at the Kayenta Mine are described in Chapter 1.0. The number of ponds changes as mining and reclamation proceed. In summary, by the year 2019 there will be 50 permanent impoundments, 115 temporary impoundments, and 101 reclaimed impoundments. Over the Life-of-Mine, there would be 51 permanent impoundments and 142 temporary impoundments. During reclamation over the Life-of-Mine, 241 impoundments would be reclaimed. All of these features have been or would be designed, built, and operated in accordance with federal regulations and current permit provisions. Design and construction are supervised by registered professional engineers in accordance with standard engineering practice and OSMRE-approved technical approaches.

For recent conditions, approximately half of the sediment ponds in the mine lease areas are fenced; the remainder are open to livestock. In the future, a portion of the ponds would remain after reclamation on the mine lease areas as permanent features for livestock watering (PWCC 2012 et seq.). PWCC has constructed and operated eleven impoundments on the proposed KMC that meet the Mine Safety and Health Administration criteria for dam design, construction, and inspection. These structures also have been designed, built, and maintained in accordance with regulations. Individual storage capacities of the Mine Safety and Health Administration impoundments on the Kayenta Mine operations area range from approximately 20 to 560 acre-feet.

3.7.3.3.3.4 Pond Water Quality

In general, about half of the existing ponds at the Kayenta Mine are currently open to livestock and wildlife; the remainder are fenced off from livestock. Recent repeated sampling on about 20 ponds across the Kayenta Mine has provided water quality data for these features and generally the water quality is adequate for use by wildlife and livestock consumption (**Appendix WR-2**, **Figure WR-2.1**). The data are summarized in **Appendix WR-2, Tables WR-2.1** through **WR-2.3**.

3.7.3.4 Transmission Systems and Communication Sites

The alignments of the transmission system associated with NGS are depicted in **Figure 1-14**. Principal stream crossings along the transmission system are listed in **Appendix WR-8, Table WR-8.22**.-Most of these channels are dry, sandy washes that only flow in response to precipitation. A few streams (or stream reaches) are intermittent or perennial. These have longer seasonal or year-around flows supported by groundwater contributions or by outflows from nearby reservoirs or conveyances. Numerous smaller ephemeral and intermittent washes not listed in **Appendix WR-8** also are crossed by the transmission line alignments. The following streams have perennial flow segments in or near the transmission line ROWs:

- WTS – Colorado River, Paria River, Muddy River, Virgin River, Las Vegas Wash, and Meadow Valley Wash.
- STS – Agua Fria River, Big Bug Creek, and Verde River.

Some of these crossings are located in deep canyons that are spanned by transmission lines high overhead. Others are simply shallow washes where transmission structures have been placed on nearby uplands. Habitats and riparian conditions along streams and washes are described in their respective resource sections of the EIS.

3.7.4 Environmental Consequences

3.7.4.1 Issues, Assumptions, and Impact Methodology

The impact assessments for water resources address issues or concerns received as project input during public and agency scoping during 2014 and in subsequent meetings. Oral and written comments were received from public participants, cooperating agencies, and tribal interactions. The water resources assessment addresses potential impacts from a Western scientific viewpoint. The evaluations are based on collection and review of agency and private data, including previous National Environmental Policy Act (NEPA) documents. Groundwater levels, channel flow data, water quality information and spring surveys were among the information sources used. Resource considerations from public scoping meetings and agency interactions guided the process.

Potential impacts to surface water and shallow groundwater (the alluvial and Wepo aquifers) were assessed from existing monitoring data collected over time, established designated uses per water quality standards, published agency reports, and permit documents. These materials are cited in the discussions. Assessments for the deeper groundwater zones (the D-Aquifer and N-Aquifer) used a combination of existing data from agencies, SRP, and PWCC, as well as new inventories and numerical computer modeling.

Since the effects of groundwater drawdown in the N-Aquifer are a major concern identified during public scoping, a numerical groundwater model was used to predict future effects. The prediction period extends to the Year 2110; hence the application of a predictive computer model. The USGS was tasked with independently reviewing and discussing available groundwater models with the EIS team, and the agency provided input to the modeling effort. A separate USGS document related to that effort has been prepared (Leake et. al 2016). As part of this EIS, summaries of groundwater modeling and the USGS work are presented in **Appendices WR-9** and **WR-10**.

The effects of different actions were estimated by the model in a manner which takes into account historical effects and other pumping scenarios. For example, the effects of Peabody's pumping through the end of 2019 were calculated by running two different simulations. One of the simulations included all (community and Peabody production) historical and predicted pumping through 2019, while the other eliminated the Peabody wells. The differences between the model's output for these two simulations provide the effects of Peabody's pumping. Another comparison was performed to evaluate the effects of the Proposed Action. The two simulations used for this comparison were (1) a simulation with historical pumping, projected tribal pumping through 2110, and project-related PWCC pumping through 2055, and (2) a simulation with historical pumping, projected Tribal pumping through 2110, and No Action pumping by PWCC through 2033 (because of pumping associated with reclamation activities). The differences in this case provide the effects of pumping associated with the Proposed Action. Calculating the effects in this manner is required because the groundwater system is currently recovering from the effects of greater pumping (through 2005) by PWCC.

In addition, an inventory of regional springs that discharge from the N-Aquifer was conducted by the USGS for the EIS (Leake et al. 2016). This involved new inventory work, as well as subsequent interactions with the EIS team to cross reference the new results with earlier inventories in the region. A summary of spring inventory work for the EIS is presented in **Appendix WR-10.**

3.7.4.1.1 Navajo Generating Station

For the NGS, scoping concerns or issues addressed by the water resources assessment include:

- Additional disposal of dry coal combustion products in the existing or expanded ash disposal area could adversely affect surface water or groundwater quantity or quality.
- Spills or leaks from water use at NGS, existing or new fluid storage, or evaporation ponds could adversely impact surface water or groundwater resources.
- Water withdrawals from Lake Powell for NGS operations could affect the water level and surface area of the reservoir.
- Airborne deposition of trace elements and/or acid-forming constituents could change water quality to conditions other than typical regional background values, or to exceedances of relevant water quality standards.

3.7.4.1.2 Proposed Kayenta Mine Complex

For the proposed KMC, scoping concerns or issues addressed by the water resources assessment include:

- Groundwater drawdown from mine-related pumping at the proposed KMC could reduce water levels in N-Aquifer public water supply wells.
- Proposed pumping could reduce N-Aquifer water quality by increasing leakage from the D-Aquifer across the Carmel Formation.
- Flow reductions at springs/seeps could occur as a result of proposed mine-related pumping at the proposed KMC (D- and N-Aquifers).
- Regional flow reductions along streams supported by the N-Aquifer may result from proposed mine-related groundwater pumping.
- Pumping withdrawals from the N-Aquifer could be reduced by developing a D-Aquifer supply for mining and reclamation activities. This could improve the long-term sustainability of the N-Aquifer.
- Groundwater drawdown in the Wepo Formation could occur from mine pit development and reclamation. This could reduce supplies to formation wells or contributions to connected springs and alluvium.
- Water quality in the Wepo Formation could be reduced by mining and reclamation activities with additional effects on hydrologically connected seeps, springs, channel baseflows, and alluvial deposits.
- The <u>quantity</u> of water in alluvial deposits could be reduced by mining activities such as pit development, water management, and reclamation. This could affect existing uses such as livestock watering or riparian habitat.
- The <u>quality</u> of water in alluvial deposits could be reduced by mining activities. This could affect existing uses such as livestock watering or riparian habitat.
- Streamflows and related designated uses downstream along Moenkopi Wash or Dinnebito Wash could be reduced by water retained in additional ponds and impoundments at the proposed KMC.
- Surface water quality could be reduced by mining activities and discharges from the proposed KMC, and that could impact designated uses downstream along Moenkopi Wash or Dinnebito Wash.

- Ponds and impoundments at the proposed KMC might not be adequately built or maintained to control runoff and provide supplemental water supplies. Water quality in ponds and impoundments may not be suitable for existing designated uses.

3.7.4.1.3 Transmission Systems and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

For the transmission systems, scoping concerns or issues addressed by the water resources assessment include:

- Water quality in streams crossed by transmission lines could be reduced by maintenance activities in the transmission line ROWs.

3.7.4.2 Proposed Action

3.7.4.2.1 Navajo Generating Station

3.7.4.2.1.1 Ash Disposal Area

- Scoping Concern: Additional disposal of dry coal combustion products in the existing or expanded ash disposal area could adversely affect surface water or groundwater quantity or quality.

Impacts from On-site Disposal of CCRs, 3-Unit Operation	Impacts from On-site Disposal of CCRs, 2-Unit Operation
The existing disposal facility would continue to be used, but would be expanded when needed using appropriate design and construction methods in accordance with regulations and agency interactions. Roughly 80 acres of additional upland watershed area would be disturbed for additional dry ash disposal. Water monitoring and site inspections would continue. No impacts to water resources would occur at the facility.	The existing dry ash disposal area would provide sufficient storage through the Year 2044. Water monitoring and site inspections would continue. No observable impacts to water resources would occur at the facility.

Disposal of dry coal combustion residuals would occur at NGS under either Proposed Action options. As described in Chapter 1.0, remaining storage capacity at the existing ash landfill is adequate for the 2-Unit Operation through the Year 2044. Additional runoff and run-on control features and other practices to protect water resources would be implemented in accordance with agency requirements. Expansion of dry-ash storage capacity would be required at some time under the 3-Unit Operation. If an expansion is necessary, it would be constructed as a northward extension of the existing landfill area on similar terrain. Contouring and compaction, a protective terraced berm, and additional surface drainage controls on surrounding lands would be incorporated in any new facility construction.

Groundwater monitoring and site inspections are part of existing site management by SRP. These would continue with either Proposed Action options, in accordance with USEPA regulatory programs (Coal Combustion Residuals Rule) and the NGS-specific Groundwater Protection Plan. Water in the N-Aquifer is approximately 824 feet or more below the ground surface at Well DW-3 at the dry ash disposal area. The original layers of fly ash and bottom ash were placed as engineered fill and were compacted at optimum moisture with a sheep's foot vibrating compactor. Subsequent borings (and boring refusals) indicate that the original layers are the strength of lean concrete, and provide a barrier to the aquifer over 800 feet below (**Appendix 1B**). Further dry ash landfill construction information is presented in the

Groundwater Protection Plan of **Appendix 1B.** Additional subsurface moisture conditions have periodically been investigated by neutron logging at several boreholes, both at the plant and the dry ash disposal landfill. These efforts and respective well locations are detailed in Appendix 2 of Appendix C of **Appendix 1B**. Although dust suppression water is applied to the dry ash landfill, no saturated conditions occurred in Well N-72 logged to a depth of 440 feet bgs in 1997 (**Appendix 1B**). This borehole is located in the north central part of the dry ash landfill (**Appendix 1B**). Outside the dry ash landfill, fracture flow (roughly 1 to 2 gpm) was noted in Well DW-3 at approximately 569 feet bgs in 1997 and again in 2015. That well has since been cased to prevent vertical conduit issues. Moisture conditions at depth in DW-3 have been relatively unchanged between 1997 and 2015 (**Appendix 1B**). Past monitoring of both neutron wells and water quality in deep wells found that the dry ash disposal area is not leaking or contributing to moisture in the Navajo sandstone below the site (**Appendix 1B**). Based on available information, no impacts to surface water or groundwater quantity or quality have occurred at the dry ash disposal facility under existing conditions. With continued operations and regulatory compliance, no impacts to groundwater resources would occur at the dry ash landfill under either Proposed Action option.

For the Proposed Action 3-Unit Operation, additional storage capacity would remove a comparatively small area from contributing to surface water runoff. Given the existing acreage and capacity (765 acres for 38 million cubic yards), additional storage for an estimated 3.7 million cubic yards would likely involve a dry, upland area of roughly 80 acres or less. This would not noticeably affect surface water yield from the arid area.

The current Groundwater Protection Plan, due to the staged implementation of the USEPA Coal Combustion Residuals Rule, is the current mechanism to ensure groundwater monitoring and site inspections are conducted for the ash landfill area. The inspection mechanism under the Coal Combustion Residuals Rule (Inspections: §257.84) is two-fold, with a seven-day Coal Combustion Residuals Landfill inspection that began no later than October 19, 2015, and an annual Coal Combustion Residuals Landfill inspection that commenced no later than January 18, 2016, per the rule. One outcome of these inspections was a recommendation to repair eroded areas of the existing landfill. SRP will conduct maintenance in compliance with requirements.

Additionally the USEPA Coal Combustion Residuals Rule requires the owner or operator of the Coal Combustion Residuals Landfill to be in compliance with the groundwater monitoring requirements (Groundwater Monitoring and Corrective Actions: §257.90-§257.98) no later than October 17, 2017. Coal Combustion Residuals compliance activities related to the Coal Combustion Residuals Landfill that must be implemented no later than October 17, 2017, include investigation of the hydrogeological setting, periodic inspections and maintenance activities, installation of a groundwater monitoring system, development of a groundwater sampling and analysis plan, conducting baseline monitoring to establish background levels, initiating a detection monitoring program and beginning to evaluate the groundwater monitoring data for statistically significant increases over background levels. Until October 17, 2017, the NGS Groundwater Protection Plan will continue the Coal Combustion Residuals Landfill groundwater monitoring and site inspections; after that date the Groundwater Protection Plan will be re-drafted to cover the NGS plant site, and the Coal Combustion Residuals rule will be utilized for the Coal Combustion Residuals Landfill components. The O&M Plan will be updated to include this transition for the Coal Combustion Residuals Landfill from the Groundwater Protection Plan program management to the Coal Combustion Residuals rule.

Closure and post-closure activities at the ash disposal landfill would be planned and implemented under the direction of a registered Professional Engineer according to accepted professional engineering practices, and in accordance with the Groundwater Protection Plan and Coal Combustion Residuals Rule. Closure and post-closure activities are described further in the Coal Combustion Residuals Ash Disposal Landfill Requirements and the NGS Groundwater Protection Plan (Appendices B and C, respectively, included as parts of **Appendix 1B**). Because of these measures, no impacts to water resources would occur at the facility under the 3-Unit Operation or 2-Unit Operation.

3.7.4.2.1.2 Water Use at NGS and Storage in Existing and New Ponds

- Scoping Concern: Spills or leaks from water use at the plant, or existing or new fluid storage or evaporation ponds, could adversely impact surface water or groundwater resources.

Impacts from Water Use at the plant, Existing or New Storage Ponds, 3-Unit Operation	Impacts from Plant Water Use, Existing or New Storage Ponds, 2-Unit Operation
No water resources impacts are anticipated from ongoing uses of water at NGS under proposed operations and maintenance. Activities conducted through the Groundwater Protection Plan (e.g., the Perched Water Dewatering Plan), facility inspections, and maintenance would continue to monitor water resources and appropriately implement mitigation. Impacts to water resources from any new ponds would be avoided by proposed engineered design and construction, monitoring, and maintenance. Ongoing implementation of the Perched Water Dewatering Plan would continue to avoid impacts from leakage at the plant site. Closure and post-closure practices would avoid impacts during those phases.	Potential impacts would be the same as those described for the 3-Unit Operation.

As described in Chapter 1.0, expansion of other process components, disposal areas, or containment features would occur at NGS with either the 3-Unit Operation or the 2-Unit Operation. Likely expansions would include the water treatment (evaporation) ponds. Existing fluid ponds would continue to be used, and new ponds may be constructed to facilitate the efficient operation of the zero discharge facility. Any new pond constructed in the near-term or future would be within the existing plant site and would meet the standards defined in the Groundwater Protection Plan. Any additional ponds would be constructed with liners and leak detection systems appropriate to their use and fluid contents.

The Perched Water Dewatering Work Plan (**Appendix 1B**) describes the extraction of perched water by existing NGS wells, and its discharge back to plant process streams for re-use. Discharge sampling and overall program reporting are part of the ongoing activities under this agency-approved plan. Because of the previous implementation and ongoing operation of this plan, no impacts to the N-Aquifer would occur from plant leakage at NGS. No impacts to surface water or groundwater resources (i.e., N-Aquifer) have been identified at NGS from the use of water at NGS, including the existing solution and evaporation ponds. No impacts are anticipated from continued uses of existing ponds or from additional ponds, because they would be built, inspected and maintained as described above (see **Appendix 1B** for more detail) during the life-of-project.

Closure and post-closure activities related to water resources are described further in the NGS Groundwater Protection Plan. For ponds, closure and post-closure activities for ponds would be planned and implemented according to accepted professional engineering practices in accordance with the Groundwater Protection Plan (**Appendix 1B**). Decommissioning practices and post-closure activities, including a comprehensive environmental site assessment and other practices, are further described in Chapter 1.0 and **Appendix 1B**. In summary, activities and practices related to water resources will include the following (**Appendix 1B**):

- Soil sampling (and remediation if necessary) will be carried out, and practices for site stabilization, capping, and controlling runoff/run-on and erosion will be implemented;

- The draining, testing, and disposal of fluids will follow applicable USEPA regulations. The final determination of closure actions would depend on test results;
- For covering process wastewater ponds and landfills, the general requirements, conceptual approaches, design and construction, maintenance, and duration of responsibility will be determined and implemented according to future engineering studies and recommendations developed in coordination with applicable regulatory programs;
- Post-closure monitoring would be determined through future engineering studies and recommendations by a Professional Engineer; these could include maintaining the existing the monitoring system and protocols as described in the Groundwater Protection Plan. Post-closure monitoring will require establishing an agreement with the Navajo Nation for access.
- Well closure/abandonment, and testing of existing or newly constructed pond liners followed by on-site burial or disposal, will be conducted according to future engineering studies and recommendations developed in coordination with applicable regulatory programs. Wells necessary for post-closure monitoring would be retained.

Based on the successful planning and implementation of these protocols and practices, no impacts to water resources during closure activities or the post-closure period would occur from either Proposed Action option.

3.7.4.2.1.3 Lake Powell

- Scoping Concern: Water withdrawals from Lake Powell for NGS operations could affect the water level and surface area of the reservoir.

Impacts from NGS Withdrawals, 3-Unit Operation	Impacts from NGS Withdrawals, 2-Unit Operation
Under full pool conditions, pumping of 29,000 acre-feet per year from Lake Powell would reduce the nominal reservoir water level by about 2 inches. The surface area would be reduced by about 132 acres. Under severe drought conditions, the nominal reservoir water level would decline by about 4.5 inches, and the surface area would be reduced by about 167 acres.	Under full pool conditions, pumping of 18,700 acre-feet per year from Lake Powell would reduce the nominal reservoir water level by about 1.4 inches. The surface area would be reduced by about 88 acres. Under severe drought conditions, the nominal reservoir water level would decline by about 3 inches, and the surface area would be reduced by about 112 acres.

Under the Proposed Action, withdrawals from Lake Powell would continue to occur as needed to supply NGS operations. For the 3-Unit Operation, approximately 29,000 acre-feet per year would be withdrawn from the lake using the deep intakes, pump station, and pipelines described in the Affected Environment sections and in Chapter 1.0.

An annual withdrawal of 29,000 acre-feet at NGS would represent approximately 0.11 percent of total reservoir water capacity at a pool elevation 3,700 feet, based on recent information (Reclamation 2007). At an elevation of 3,700 feet, Lake Powell has a surface area of approximately 160,784 acres

The lowest recorded pool elevation for Lake Powell occurred at 3,555.1 feet in early April 2005. At that elevation, an annual withdrawal of 29,000 acre-feet would represent about 0.28 percent of total reservoir water capacity. At an elevation of 3,555 feet, Lake Powell has a surface area of approximately 73,787 acres.

Under the Proposed Action, 2-Unit Operation, approximately 19,340 acre-feet would be withdrawn annually by NGS. An annual withdrawal of this amount would represent approximately 0.07 percent of reservoir storage at an elevation of 3,700 feet.

Because of the small incremental changes projected above, and the normal variations in Lake Powell pool elevations, wind and rain effects, and annual and seasonal inflows, there would be negligible impacts from NGS withdrawals under either Proposed Action options. No impacts would occur from the continued operation or maintenance of the existing water intake, pump station, or water supply pipelines.

- Scoping Concern: Airborne deposition of trace elements of concern (arsenic, mercury, selenium) and/or acid-forming constituents could change water quality within a 20-km radius of the station to conditions other than typical regional background values, or to exceedances of relevant water quality standards.

Impacts to Surface Water Quality from NGS Airborne Deposition, 3-Unit Operation	**Impacts to Surface Water Quality from NGS Airborne Deposition, 2-Unit Operation**
Very low rates of arsenic, mercury, or selenium deposition from NGS are predicted within the 20-km study area. Negligible impacts to water quality from these trace elements would result from the 3-Unit Operation. Negligible impacts from NGS acid deposition factors would occur.	Water quality impacts would be similar to, but less than, the negligible impacts described for the 3-Unit Operation.

Three trace elements were defined during the ERA work as being of potential concern: arsenic, mercury, and selenium. These constituents would be deposited on surface waterbodies by stack emissions from the NGS. The potential deposition concentrations and rates were determined by air quality modeling as described in Section 3.1. Predicted water concentrations due to deposition for the three trace elements on surface water are depicted on bar charts in the ERA appendix (**Appendix 3RA**). For arsenic, predicted water deposition concentrations are generally similar for both total and dissolved forms, approximately 0.0000013 mg/L (approximately 0.0013 µg/L). This is a negligible increase in water concentration due to deposition in comparison to existing background concentrations in Lake Powell and in the rivers regionally (see **Table 3.7-7** and **Appendix WR-8** information for Lake Powell, Colorado River, San Juan River). For total and dissolved mercury, predicted water deposition concentrations varied between 0.000000055 mg/L to 0.0000000032 mg/L (0.000055 to 0.0000032 µg/L) for the two Proposed Action options. Again, these are negligible compared to background values, and would not be detected by most laboratory water analyses. For selenium, predicted total and dissolved water deposition concentrations are approximately 0.00001 mg/L (0.01 µg/L) for the 3-Unit Operation, and about 0.000007 mg/L (0.007 µg/L) for the 2-Unit Operation (**Appendix 3RA**).

For the constituents of interest (arsenic, mercury, and selenium) the aquatic use chronic standards are as follows (Arizona Department of Environmental Quality 2016; NNEPA 2008; UDEQ-DWR 2016):

- Arsenic, dissolved, micrograms per liter: 150 (NNEPA); 150 (Utah); 150 (Arizona)
- Mercury, dissolved, micrograms per liter: 0.001 (NNEPA); 0.012 (Utah); 0.01 (Arizona)
- Selenium, dissolved (D) or total (T): micrograms per liter: 2.0 D (NNEPA); 4.6 D (Utah); 2.0 T (Arizona)

Arsenic and mercury constituent concentrations are within applicable chronic aquatic and wildlife standards for the Navajo Nation, State of Utah, and State of Arizona. As listed in **Table 3.7-7**, average background dissolved arsenic levels in Lake Powell and the Colorado River downstream (in the 20-km study area) range from 1.4 to 1.7 µg/L. With predicted deposition, arsenic concentrations would remain within water quality standards. Average background dissolved mercury concentrations range from 0.0004 to 0.0007 µg/L in Lake Powell and the Colorado River downstream (in the 20-km study area), as listed in **Table 3.7-7**. With predicted deposition, mercury concentrations would remain within water quality standards.

At most locations existing selenium concentrations are within standards, but in some cases are already at or above the standards for Arizona and NNEPA. Dissolved selenium concentrations in lower Lake Powell already numerically approach or exceed these standards (**Tables 3.7-7** and **Appendix WR-8, Table WR-8.13**). Background average selenium values in Lake Powell and the Colorado River downstream (in the 20-km study area) range from 1.5 to 2.2 µg/L. With predicted deposition, selenium concentrations would still closely reflect these existing conditions. Arizona water quality standards note that exceedances due to natural background conditions are not violations (Arizona Department of Environmental Quality 2016). Predicted water concentrations due to deposition of selenium, arsenic, and mercury would be negligible in comparison to existing concentrations. With additional inflows, outflows, and wave action on the reservoir, water quality impacts from predicted deposition of these constituents would be negligible.

Acid deposition was previously discussed in the Air Quality assessment, Section 3.1. The deposition rates were evaluated at 59 separate lakes and streams in Arizona, Colorado, and Utah. Cumulative sources would create major impacts at one waterbody (Section 3.1). The Anasazi Pond near Spillway, Utah was predicted to undergo 0.45 kg/hectare-year for sulfur deposition and 2.17 kg/hectare-year for nitrogen deposition. This is a major cumulative impact at this one location, but the NGS contribution is considered negligible. The NGS contribution at this receptor was approximately 2 to 3 percent of the total cumulative deposition. Because of this, acid-forming deposition impacts to surface water quality from NGS are considered negligible. Additional discussion of this issue is presented in Section 3.1.

3.7.4.2.2 Proposed Kayenta Mine Complex

3.7.4.2.2.1 N-Aquifer Water Levels, Water Quality, and Uses

- Scoping Concern: Groundwater drawdown from mine-related pumping at the proposed KMC could reduce water levels in N-Aquifer public water supply wells.

Impacts of Mine-Related Pumping on N-Aquifer Wells, 3-Unit Operation	Impacts of Mine-Related Pumping on N-Aquifer Wells, 2-Unit Operation
In and near the coal leasehold, mine-related pumping effects are predicted to create maximum N-Aquifer drawdowns of 50 to 100 feet or more. Farther from the mine pumping wells, predicted N-Aquifer drawdowns would be less. Maximum drawdowns of approximately 35 feet would occur at Forest Lake, and about 16 feet would occur at Pinon. Maximum drawdowns of approximately 14 feet would occur at Kayenta, with about 5.5 feet at Keams Canyon, and about 2.5 feet at Kykotsmovi and Rough Rock. In terms of groundwater uses, such mine-related drawdowns would create none to negligible impacts to N-Aquifer public water supply wells. Project-related impacts to pumping lift heights would be none to negligible since the predicted range in percent increased lift would vary from 0 to 3.7 percent. Maximum predicted N-Aquifer drawdowns would occur in different years at different locations.	Potential impacts would be the same as those described for the 3-Unit Operation.

The impact of pumping at the proposed KMC on water levels in the N-Aquifer has been assessed by estimating the change in water level (drawdown) in wells within the area of impact due to pumping. **Table 3.7-13** lists planned annual pumping from PWCC's NAV production wells during the Proposed Action. For purposes of the EIS, it is assumed that mine-related water demand for potable supply, fire suppression, and dust suppression (e.g., on haul roads, access roads, and facilities such as shops and storage areas) would be the same under the 2-Unit Operation as under the 3-Unit Operation. This assumption is based on the locations of proposed active coal resource zones, maintenance of related road and conveyor networks, and the continued need for similar water uses at the proposed KMC.

Table 3.7-13 Anticipated N-Aquifer Withdrawals for the Proposed KMC Operations

Years	Annual Withdrawals (acre-feet)
2020 - 2044	1,200
2045 - 2047	500
2048 - 2057	100

The estimate of future water level change is supported by a revised numerical model of Black Mesa prepared for PWCC by Tetra Tech, Inc. (Tetra Tech 2014). The PWCC groundwater flow model is a three-dimensional numerical model of the Black Mesa area. It is comprised of seven layers representing the D-Aquifer (Dakota, Morrison, Entrada/Cow Springs Member of the Entrada Sandstone), the Carmel Formation which serves as a confining bed for the underlying N-Aquifer (Navajo, Kayenta, and Wingate formations). The current model has been reviewed by the USGS and determined to be suitable for use in predicting water level change in N-Aquifer wells within the model domain (Leake et al. 2016). Details of the model, model files, and the USGS review are presented in **Appendices WR-9** and **WR-10**.

Numerical groundwater flow models are acknowledged to be "non-unique", meaning that more than one set of boundary conditions and aquifer parameters can produce essentially the same 'fit' to measured conditions. In the case of the current PWCC 3-D Groundwater Flow Model of the D- and N-Aquifers there are several aspects of model development that have constrained the selection of boundary conditions and model inputs. These are discussed in detail in **Appendix WR-9** and summarized below.

- There has been a rigorous annual pumping, water level, spring discharge, surface water flow and water quality data collection program by the USGS since 1971. These data have provided a reliable record of change in response to groundwater withdrawals.
- At least three other groundwater flow models of the same area and aquifers have been constructed. These models were independently developed and have provided a similar 'fit' to measured data with different model configurations.
- The current model was subjected to 'peer review' by the USGS. This review "found no problems with the PWCC model that would preclude its use by the NGS-KMC EIS team".

Modeling of the response to proposed future PWCC pumping on Black Mesa has benefited from the fact that past pumping has exceeded projected pumping by a factor of 4.5. Thus, the level of stress to be imposed on the aquifers by future PWCC pumping has been measured and the model calibrated to past PWCC induced changes in groundwater levels that are greater than those going forward. Furthermore the length of future PWCC pumping is limited to 45 years, minimizing the length of the projection period and the uncertainty associated with unknowable future conditions.

Community pumping is projected to 2110 (98 years), the total annual pumpage increases nearly six times and exceeds the maximum PWCC past pumping by a factor of four. Thus, uncertainty in model simulation of future water level conditions past the end of PWCC pumping (2057) is increased.

As discussed in **Appendix WR-9**, the accuracy of the simulation of past and future water levels varies throughout the model domain. In general the model produces good to very good 'fit' to measured water levels in the area of the leasehold and in major community pumping centers. The fit is poorer in areas distant from the leasehold and near the confined-unconfined N-Aquifer boundary.

Originally developed in 1999, the pumping data set for the model has been updated several times. In 2013-2014 the model was converted to the more recent USGS MODFLOW-NWT version, re-calibrated (using parameter estimation software) and updated with water level and pumping data through 2012. The model was calibrated by simulating measured water levels and stream and spring flow from 1956 through 2012. Pumping by PWCC at the Black Mesa-Kayenta leasehold began in the early 1970s. The model includes both PWCC pumping, municipal groundwater withdrawals by Navajo and Hopi communities and pumping from windmills from 1956 through 2012 (Tetra Tech 2014). In this report all references to ‘community’ pumping or withdrawal includes estimated withdrawal from windmills, even if not explicitly stated.

The model domain in relation to key geographic and project features is shown on **Appendix WR-8, Figures WR-8.6** and **WR-8.7**. As presented in Appendix B, Table B-5 of the 2011 Permit Renewal Environmental Assessment (OSMRE 2011a), total historical withdrawals from the N-Aquifer increased from about 70 to 8,000 acre-feet per year from 1965 to 2002, with the major increase due to industrial use by the wells for PWCC operations. In 1982 water use at the mine reached a maximum of 4,740 acre-feet per year. PWCC greatly reduced its N-Aquifer pumping at the end of 2005, when the coal slurry pipeline to the Mohave Power Plant ceased operations. Mine-related pumping has since been reduced to 1,584 acre-feet per year (as of 2014), and is projected to be reduced further under the Proposed Action as noted above.

Effects on water levels spread out unevenly over time, while the aquifer responds to pumping or to changes in pumping rates. There are time lags in these responses. Thus, the maximum impact of mine-related pumping occurs at different times in different locations. The PWCC model was run to estimate the time at which N-Aquifer water level declines of greater than 1 foot due to the Proposed Action pumping would begin to recover. This analysis predicted that maximum impacts due to mine-related pumping would be reached prior to 2111 (Tetra Tech 2014).

Predicted maximum mine-related drawdown due to the Proposed Action (3-Unit Operation) pumping is shown on **Figure 3.7-12**. Maximum drawdown at key community wells is given in **Table 3.7-14**, along with the year in which the maximum mine-related drawdown is predicted to occur. This table presents the maximum drawdown at each community; if a community has multiple wells, the value in the table is for the well with the greatest predicted drawdown. Smaller drawdowns occur in years other than those identified in **Table 3.7-14**, but they would be lesser effects. The table indicates the maximum predicted mine-related drawdown effect based on the model simulations. Note that the table presents the drawdown value for a single pumping scenario, assuming that N-Aquifer groundwater demand at the proposed KMC would be similar under either Proposed Action options.

As shown on **Figure 3.7-12**, the largest drawdown occurs nearest to the coal leasehold and PWCC NAV water supply wells, ranging from about 100 feet to about 50 feet. Drawdown also is greater in the confined area of the N-Aquifer due to the lower storage coefficient of the aquifer in this area. This is reflected in **Table 3.7-14**, where community wells within the confined zone and nearest the leasehold, such as Forest Lake and Chilchinbito, have the greatest maximum drawdown.

As identified in **Table 3.7-14**, the maximum simulated project-related drawdown would not occur everywhere in the N-Aquifer at the same time. For example, **Table 3.7-14** shows that Rocky Ridge and Low Mountain would have approximately the same simulated maximum drawdown (12.08 feet and 12.19 feet, respectively, but the years when this would occur are 2050 at Rocky Ridge and 2055 at Low Mountain. Similarly, the simulated maximum drawdown from Proposed Action pumping is 2.49 feet at both Rough Rock and Kykotsmovi, but this is estimated to occur in 2052 at Kykotsmovi and 2055 at Rough Rock. Thus, it should be clear that the drawdown contours depicted on **Figure 3.7-12** are spatial in nature, but that the timing of drawdown would vary between specific locations.

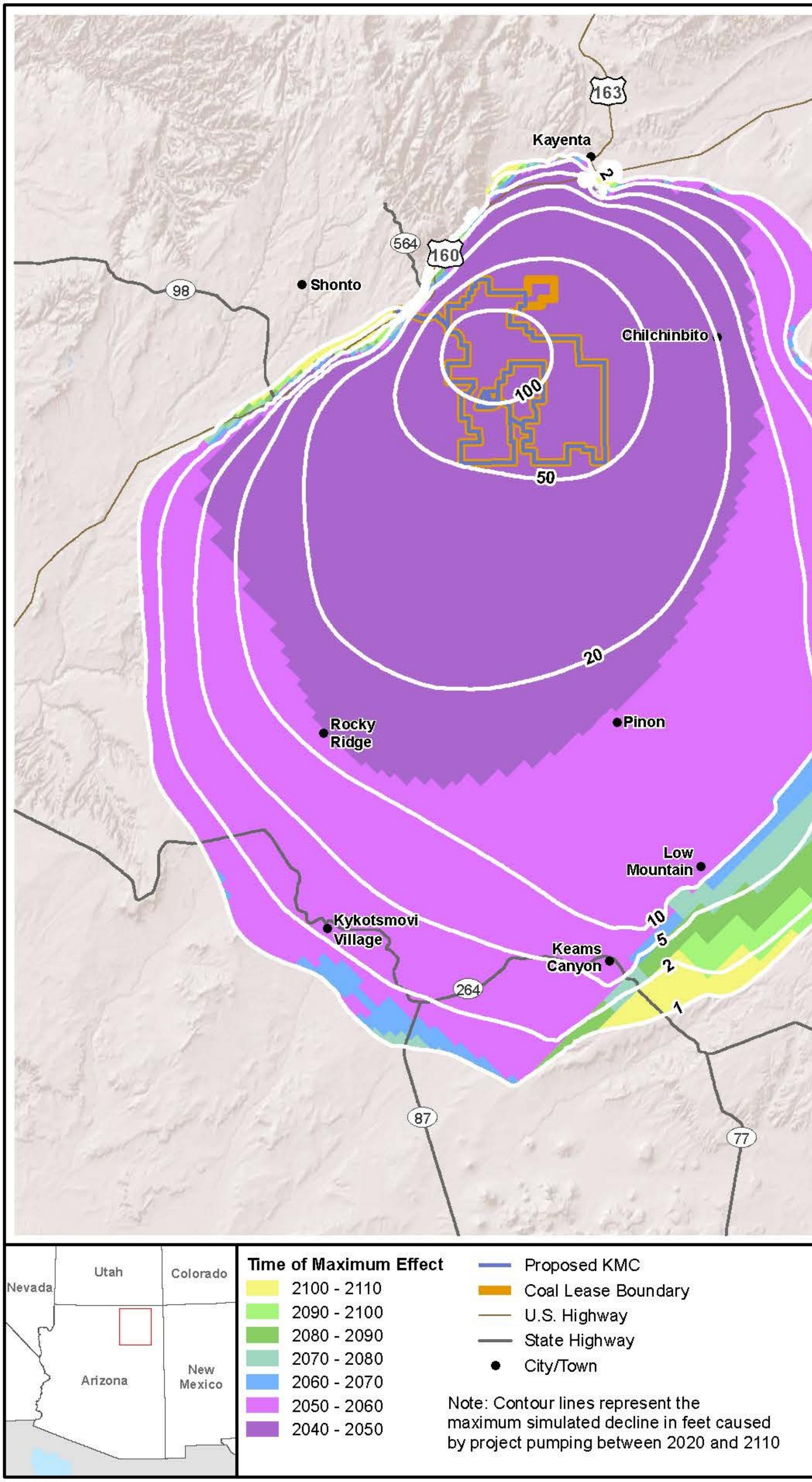

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Figure 3.7-12
N-Aquifer Maximum Mine-Related Proposed Action Pumping Drawdown

7/20/2016

Table 3.7-14 Maximum Drawdown at Key Community Production Wells from Mine-Related Proposed Action Pumping

Community	Maximum Drawdown (feet) and Its Year of Occurrence [1]	
	3-Unit Operation	2-Unit Operation
Navajo		
Kayenta	13.73 feet, in 2097	Same
Shonto	0.01 feet, in 2040	Same
Dennehotso	0.01 feet, in 2063	Same
Chilchinbito	18.50 feet, in 2049	Same
Rough Rock	2.49 feet, in 2055	Same
Forest Lake	35.26 feet, in 2046	Same
Pinon	15.71 feet, in 2051	Same
Hard Rock	16.10 feet, in 2049	Same
Low Mountain	12.19 feet, in 2055	Same
Shonto Junction	0.23 feet, in 2109	Same
Red Lake	0.09 feet, in 2108	Same
Rocky Ridge	12.08 feet, in 2050	Same
Tuba City	0.01 feet, in 2065	Same
Hopi		
Moenkopi	0.05 feet, in 2096	Same
Hotevilla	2.69 feet, in 2053	Same
Bacavi	2.57 feet, in 2054	Same
Hopi High School	3.73 feet, in 2055	Same
Keams Canyon	5.54 feet, in 2054	Same
Mishongnovi	2.04 feet, in 2057	Same
Second Mesa	1.82 feet, in 2060	Same
Kykotsmovi	2.49 feet, in 2052	Same
Hopi Civic Center	2.77 feet, in 2053	Same
Hopi Cultural Center	2.8 feet, in 2092	Same
Shungopavi	2.0 feet in 2055	Same
Sipaulovi	1.84 feet, in 2056	Same
Polacca	3.89 feet, in 2055	Same
HAMP	11.75 feet, in 2051	Same

[1] If a community has multiple N-Aquifer wells, the value in the table reflects the well with the greatest predicted drawdown.

HAMP = Hopi Arsenic Mitigation Project.

The impact of drawdown due to pumping at the proposed KMC would be to lower the water level in surrounding wells, thereby increasing the amount of lift (in feet) required to bring water to the ground surface. An assessment of the degree of impact at a given well is the percent increase in lift caused by Proposed Action pumping. The percent increase is based on the predicted feet of lift needed at the maximum simulated drawdown from the Proposed Action, compared to the existing feet of lift presently needed under current conditions at each well. **Table 3.7-15** gives the estimated 2019 depth to water in the community wells noted in **Table 3.7-14** at the year of maximum drawdown (including both PWCC and community withdrawals) and the percent increase in lift resulting from the maximum predicted drawdown due to the Proposed Action (PWCC) pumping.

As would be expected given its proximity to the proposed KMC leasehold, the maximum increase in lift due to the Proposed Action pumping would occur at Forest Lake. The range in percent increased lift varies from zero to 3.0 percent; the median value is 0.01 percent. Because of these small values, impacts to future pumping lifts from a Proposed Action operation would be none to negligible.

Table 3.7-15 Percent Increase in Lift at Key Community Production Wells from Mine-Related Proposed Action Pumping

Community	Estimated 2019 Depth to Water (feet bgs) [1]	Anticipated Percent Increase in Lift from Proposed Mine Pumping
Navajo		
Kayenta	820	1.7
Shonto	375	0.0
Dennehotso	32	0.0
Chilchinbito	609	3.0
Rough Rock	727	0.3
Forest Lake	1,145	3.1
Pinon	898	1.7
Hard Rock	785	2.1
Shonto Junction	179	0.1
Red Lake	238	0.0
Rocky Ridge	599	2.0
Tuba City	210	0.0
Hopi		
Moenkopi	616	0.0
Hotevilla	1,002	0.3
Bacavi	1,024	0.3
Low Mountain	833	1.5
Kykotsmovi	280	0.9
Hopi Civic Center	440	0.6
Shungopavi	964	0.2
HAMP[2]	589	2.0

[1] Depth to water is listed for the year of maximum drawdown due to PWCC pumping (see **Table 3.7-14**).

[2] Wells replace existing high arsenic wells at Hopi CC, Polacca, Mishongnovi, and Second Mesa in 2020, and Hopi HS and Keams Canyon in 2030; maximum depth to water occurs after 2030.

HAMP = Hopi Arsenic Mitigation Project.

- Scoping Concern: Proposed pumping could reduce N-Aquifer water quality by increasing leakage from the D-Aquifer across the Carmel Formation.

Impacts to N-Aquifer Water Quality could occur from Leakage Induced from the D-Aquifer by Proposed Mine-Related Pumping, 3-Unit Operation	Impacts to N-Aquifer Water Quality could occur from Leakage Induced from the D-Aquifer by Proposed Mine-Related Pumping, 2-Unit Operation
No N-Aquifer water quality impacts from Proposed Action pumping would occur at NAV wells within the coal lease areas or at wells supplying outlying communities.	Potential impacts would be the same as those described for the 3-Unit Operation.

Since groundwater levels in the D-Aquifer are significantly (100 to 250 feet) higher than in the N-Aquifer, there is a downward hydraulic gradient across the Carmel Formation that separates the two. As described previously, water quality in the D-Aquifer is somewhat poorer than in the N-Aquifer. Thus, reduced N-Aquifer water quality is a potential impact. Generally the aquifer properties of the clay-rich Carmel Formation keep leakage to very small rates near the coal leases, as discussed in the Affected Environment section. This helps maintain good water quality in the N-Aquifer. However, with drawdown occurring in the N-Aquifer from PWCC and community pumping, hydraulic head in the N-Aquifer has declined. This creates an increased downward hydraulic gradient across the Carmel Formation and induces slightly greater flow from the D-Aquifer to the N-Aquifer where leakage occurs. The estimated effects of Proposed Action pumping on water quality (i.e., sulfate concentrations) in the N-Aquifer were simulated as part of the EIS groundwater modeling effort (Tetra Tech 2015a). Available laboratory data were used to estimate the initial sulfate concentrations in both the N-Aquifer and the D-Aquifer. Using the groundwater model cells in each subarea, the new sulfate concentration in the N-Aquifer (for each year modeled) was then determined by adding both the mass of sulfate and volume of water migrating through the Carmel Formation to the mass of sulfate and volume of water in the N-Aquifer during the prior year, and calculating a new sulfate concentration. This approach assumed that the volume of water contained in the N-Aquifer at the beginning of the calculations was large compared to the volume added over the modeling timeframe (Tetra Tech 2015a). As indicated in **Table 3.7-16** below, there is essentially no change in N-Aquifer water quality due to Proposed Action pumping; the very small changes indicated would comprise essentially no Proposed Action-related impacts.

Table 3.7-16 Estimated Change in Sulfate Concentration at the End of 2110 Caused by the Proposed Action Pumping

Subarea	Initial Concentration (mg/L)		Predicted Concentration Change (mg/L)[1]	Navajo Sandstone Change[1]
	D-Aquifer	Navajo Sandstone	Navajo Sandstone	
Northeast	250	70	0.000	0.00033%
East	850	100	0.002	0.00221%
Hopi Buttes	360	50	0.000	0.00007%
Forest Lake	1,000	100	0.003	0.00268%
Kits'illie	75	30	0.000	0.00005%
Pinon	200	5	0.000	0.00078%
Rocky Ridge	250	10	0.000	0.00053%
Preston Mesa	400	10	0.000	0.00000%
Leasehold	400	30	0.004	0.01324%

Table 3.7-16 Estimated Change in Sulfate Concentration at the End of 2110 Caused by the Proposed Action Pumping

Subarea	Initial Concentration (mg/L)		Predicted Concentration Change (mg/L)[1]	Navajo Sandstone Change[1]
	D-Aquifer	Navajo Sandstone	Navajo Sandstone	
Pinon to Kits'illie	1,000	20	0.000	0.00099%
Surrounding Leasehold	100	45	0.000	0.00005%
Red Lake to Tuba City	400	50	0.000	0.00008%
Hotevilla to Kaibeto	200	35	0.000	0.00007%
Pinon to Rocky Ridge	210	140	0.000	0.00004%

[1] Rounding effects account for differences between columns.

Source: Tetra Tech 2015a.

In addition, comparison of recent N-Aquifer water quality data (**Appendix WR-7**) with early 1980s data (PWCC 2012 et seq.) indicates little or no reduction of water quality at wells in the coal leaseholds. N-Aquifer water in PWCC wells meets the standards for intended uses, including drinking water. Although NAV8 has slightly greater TDS concentrations than other NAV wells, it still has very good water quality with respect to drinking water standards. No detectable N-Aquifer water quality impacts from Proposed Action pumping would occur at NAV wells within the coal lease areas or at those supplying outlying communities. Because of this, impacts would be none to negligible.

- Scoping Concern: Regional flow reductions along streams supported by the N-Aquifer may result from proposed mine-related groundwater pumping.

Impacts to Stream Baseflows Supported by the N-Aquifer, 3-Unit Operation	Impacts to Stream Baseflows Supported by the N-Aquifer, 2-Unit Operation
Proposed mine-related pumping would generate either no or negligible reductions to stream baseflows supported by groundwater discharges from the N-Aquifer.	Potential impacts would be the same as those described for the 3-Unit Operation.

Streamflow on Black Mesa results from runoff due to rainfall on the watersheds and from groundwater discharge (baseflow) where aquifer water levels (D-Aquifer and N-Aquifer) intersect stream channels. The D- and N-Aquifers are confined beneath the proposed KMC and over much of Black Mesa, and groundwater discharge from them takes place at or beyond the boundary where the change from confined to unconfined conditions occurs. This is typically around the outer edges of the mesa. The component of streamflow potentially impacted by the proposed KMC pumping, particularly in stream segments supported by the N-Aquifer, is that due to groundwater discharge. This component is referred to as baseflow and is generally stable compared to the runoff from precipitation. Baseflows result from groundwater discharge, and in some stream reaches may be the only source of flowing water in the channel during dry periods. Baseflows are important because they support surface water uses and related habitats during dry periods.

Using the groundwater modeling previously described, stream baseflow at seven locations has been simulated using the MODFLOW Streamflow Routing Package (SFR2). Details of the model, model files, and the USGS review are presented in **Appendices WR-9** and **WR-10**.

Simulated stream baseflow locations are shown at their USGS stream gage locations on **Figure 3.7-13**. Simulated baseflows at the seven model simulated locations are given in **Table 3.7-17** for 1956 (pre-PWCC mining operations) and 2019 (with PWCC mining operations, community, and windmill pumping) (Tetra Tech 2015a,b). The 2019 baseflow values serve as the background condition for the direct and indirect impact assessments for the Proposed Action and alternatives.

The differences between the two values (1956 versus 2019 simulated values) are due to all N-Aquifer pumping (PWCC, community, and windmill) from 1956 through 2019, a total of 63 years. This includes a total historic and projected cumulative withdrawal of 295,695 acre-feet, of which PWCC pumping is 158,684 acre-feet, or 54 percent. Some of the historical baseflow reductions through Year 2019 are the result of pumping (historical and projected through 2019) by PWCC. The total simulated stream discharge in 1956 represented in **Table 3.7-17** is approximately 2.86 cfs. At the end of 2019, summing the negative values in the “Difference” column in **Table 3.7-17** shows that the overall decline (in response to combined community and PWCC pumping) is approximately 0.12 cfs (4.4 percent). Of this overall decline, 0.034 cfs is the total result of pre-2020 PWCC pumping through 2019; this is 1.2 percent of the 1956 simulated streamflow (2.86 cfs). The greatest percentage reduction between 1956 and the end of 2019 is in Polacca Wash, where the simulated effect of all pumping is a reduction of approximately 20 percent (0.025 cfs); the Peabody pumping is estimated to cause a reduction of 6.3 percent (0.0078 cfs) there.

Table 3.7-17 Simulated Baseflow 1956 Compared to the End of 2019 and Predicted Project Effects 2020 through 2110

Location[1]	USGS Station No.	1956 (cfs)	End of 2019 (cfs)	Difference (cfs)	Difference Resulting from pre-2020 PWCC Pumping (cfs)	Predicted Mine-Related Changes, 2020 through 2110 (cfs)
Moenkopi Wash	09401260	1.641	1.637	-0.004	-0.0027	-0.0004
Dinnebito Wash	09401110	0.198	0.200	0.002	0.0000	0.0000
Polacca Wash	09400568	0.124	0.099	-0.025	-0.0078	-0.0007
Chinle Creek	09379200	0.348	0.309	-0.039	-0.0105	-0.0027
Jeddito Wash	09400583	0.063	0.062	-0.001	-0.0001	0.0000
Begashibito Wash	NA	0.119	0.101	-0.018	-0.0028	0.0000
Laguna Creek	09379180	0.364	0.326	-0.038	-0.0104	-0.0027

[1] Locations are indicated on **Figure 3.7-13**.

cfs – cubic feet per second.

NA – Not Applicable – No USGS gage at this location.

For the Proposed Action, PWCC pumping would start after the end of 2019, and would consist of the annual pumping volumes for the Proposed Action options previously listed in **Table 3.7-13**.

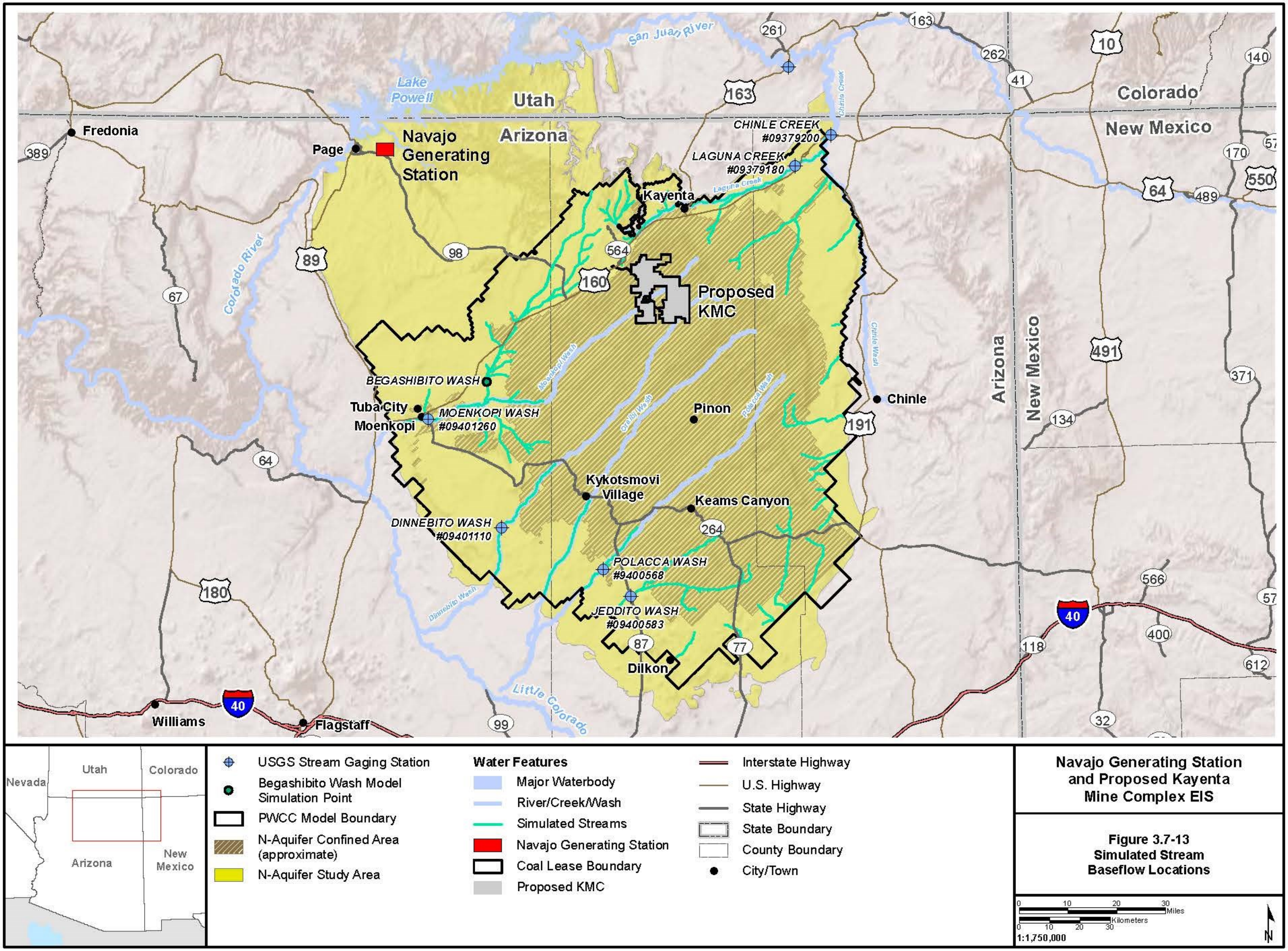

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Figure 3.7-13 Simulated Stream Baseflow Locations

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Over the projected 2020 through 2110 period, either the total PWCC 3-Unit Operation or the 2-Unit Operation pumpage is predicted to be about 32,500 acre-feet. This would be 20 percent of the historic PWCC pumping and 11 percent of the total 1956-2019 pumpage from all regional sources (by the mining operation and communities). The effects of the Proposed Action were determined by calculating the differences between pumping for the Proposed Actions and for the No Action Alternative (discussed below) at the beginning of 2020 and the end of 2110. Future total reductions from the Proposed Action (0.0065 cfs, summing the right-most column of Table 3.7-17) are predicted to be smaller than the pre-2020 reductions (0.034 cfs), by a factor of 0.19. The washes with the largest percentage reduction between 2020 and 2110 are Chinle Wash (0.87 percent or 0.0027 cfs) and Laguna Creek (0.83 percent or 0.0027 cfs).

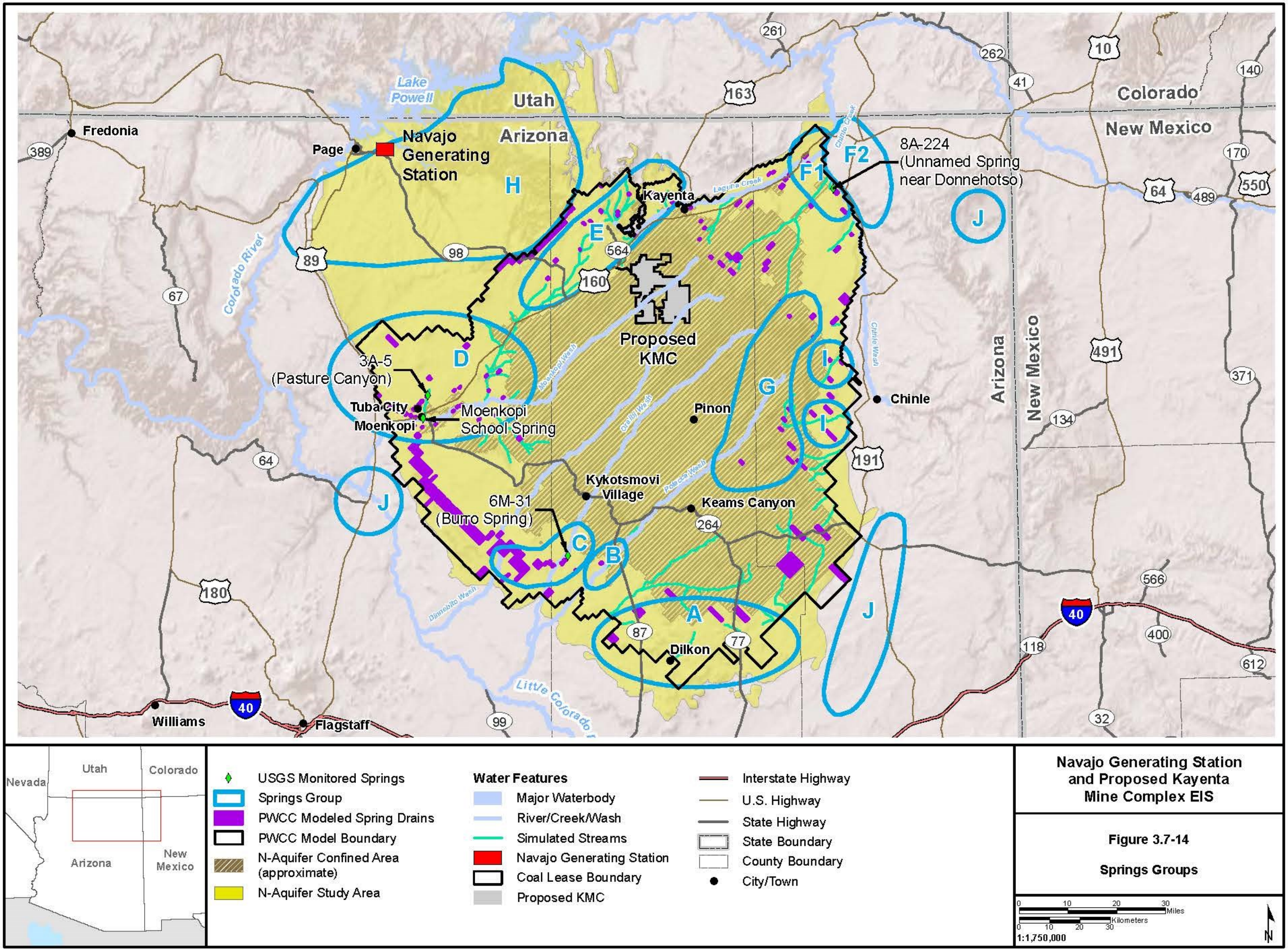
Based on the groundwater modeling results summarized in **Table 3.7-17** above, PWCC mine-related Proposed Action pumping would have no effect on background channel baseflows in Dinnebito Wash, Jeddito Wash, or Begashibito Wash. There would be almost no mine-related effect on background flows in Moenkopi Wash, and less than one percent change in Polacca Wash, Chinle Creek, or Laguna Creek as a result of mine pumping. These would be negligible effects.

- Scoping Concern: Flows at springs or the occurrence of seeps could be reduced by mine-related pumping at the proposed KMC (D- and N-Aquifers)

Impacts to N-Aquifer Springs from Proposed Mine-Related Pumping, 3-Unit Operation	Impacts to N-Aquifer Springs from Proposed Mine-Related Pumping, 2-Unit Operation
Proposed mine-related pumping would generate either no or very small reductions in flows or water levels at N-Aquifer springs. The potential impacts from either Proposed Action options would be none to negligible. PWCC has already closed or is reclaiming wells open to the D-Aquifer; no impacts to D-Aquifer springs would occur from proposed mine-related pumping. Based on the analysis of spring features, impacts to seeps also would be negligible.	Potential impacts would be the same as those described for the 3-Unit Operation.

As noted in the Affected Environment description, D- and N-Aquifer springs and seeps occur where the aquifer rocks are exposed, and the aquifer water level is at or above the land surface. In most cases these conditions are limited to the periphery of the mesa where the aquifer units are at or near the ground surface. Since springs and seeps are important perennial water sources for irrigation, cultural, and ecological purposes, and have religious or sacred values for the Navajo and Hopi people, individual spring locations are not identified in the EIS unless they have been identified in the published literature (e.g., the four USGS monitored springs: Pasture Canyon, Moenkopi School/Susunova, Burro, and Unnamed near Dennehotso).

The USGS undertook a study to identify and characterize springs identified by various methods (Leake et al. 2016). A total of 104 springs characterized as "likely" were identified as emanating from D- and N-Aquifer stratigraphic units. With the exception of the four USGS monitored springs, individual sites were not visited and no flow data are available. To facilitate the discussion of impacts of proposed mine-related pumping on springs and seeps, these features were grouped into major areas ("A" through "J") based on their geographic and hydrogeologic similarity. Spring and seep groups are shown on **Figure 3.7-14** and briefly described in **Table 3.7-18**. Additional spring information is presented in **Appendix WR-10.**



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 3.7-14

Springs Groups

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Table 3.7-18 Spring Groups Developed for Discussion Purposes

Spring Group	Number of Springs/Seeps	Location
A	8/0	Located in the Dilkon area
B	3/0	Near Polacca Wash
C	9/1	Near Oraibi Wash, includes USGS Monitored spring (Burro)
D	21/0	Near Tuba City, Moenkopi Wash and Blue Canyon; includes USGS-monitored springs (Pasture Canyon and Moenkopi School)
E	10/1	Near Shonto Wash
F1	10/0	Near Dennehotso, west side of Chinle Wash, includes USGS monitored spring (Unnamed)
F2	7/0	Near Dennehotso, east side of Chinle Wash. Outside PWCC model
G	2/1	East of Pinon, N-Aquifer thin, D-Aquifer springs
H	21/0	Kaibeto Plateau in incised canyons. Outside PWCC model
I	2/0	Near Chinle west of Chinle Wash
J	6/0	Miscellaneous, outside N-Aquifer. Outside PWCC model

As with the impact of proposed mine-related pumping on wells, the PWCC 3-D groundwater flow model is utilized to evaluate potential changes at springs and seeps due to future pumping at the proposed KMC. Model calibration targets included water elevations at springs and in wells for both the D- and N-aquifers. USGS-monitored springs are listed in **Table 3.7-19** along with the 2012 measured and modeled flow. Groundwater elevations at the springs also were modeled, and potential changes in elevations also are used in the assessment. The locations of these springs are shown on **Figure 3.7-14**.

Table 3.7-19 PWCC Model Calibration Springs

Name	USGS ID	BIA ID	2012 Measured Flow (gpm)	2012 Model Simulated Flow (gpm)
Moenkopi School	360632111131101	3GS-77-6	6.3	0.0[1]
Burro	354156110413701	6M-31	0.3	0.0[1]
Pasture Canyon [2]	09401265	3A-5	150	122
Unnamed near Dennehotso	364656109425401	8A-224	4.5	3.5

[1] Although simulated by the MODFLOW SFR2 package, zero flow was produced at the spring locations (see text).

[2] Pasture Canyon springs as estimated for the sum of discharge.

BIA = Bureau of Indian Affairs

The PWCC model simulates these monitored springs using the MODFLOW Streamflow Routing Package (SFR2). The other non-monitored springs do not have consistently measured flows; the model is not calibrated to discharge values at these locations; these springs are represented by drain cells. The stream flow routing package generates a flow value for the four monitored springs given in **Table 3.7-19**. As noted, zero flow was produced by the model at the Moenkopi School and Burro Spring sites. This is thought to be due to complexities in the local geologic environment and the limitation of vertical discretization to simulate these complexities at these locations (Tetra Tech 2014).

Moenkopi School (Susunova) Spring is located in a tongue of the Navajo Sandstone within the Kayenta Formation (**Appendix WR-10**). The Navajo Sandstone and Kayenta Formations are simulated as individual layers in the model and have significantly different hydrologic parameters. Thus, the Moenkopi Spring is simulated as though it were in the Kayenta Formation with lower conductivity and produces no flow at the spring. Burro Spring occurs within the Navajo Sandstone, but appears to be locally perched within the formation; the model is unable to simulate flow in sublayers of the formation since it is simulated a single layer. However, in both cases the model does simulate heads (water levels) at the location of the springs. A decrease in water level would result in a corresponding decrease in spring flow. Therefore, model predicted changes in head provide a surrogate for potential impacts to spring flow. Model-predicted changes in both water levels (and springs) due to Proposed Action pumping are very small, e.g., less than 0.01 foot changes in water levels.

No change in flow at the four USGS monitored springs is predicted as a result of the proposed mine-related pumping under either the 3-Unit Operation or 2-Unit Operation. As depicted on **Figure 3.7-15**, the cone of depression due to proposed mine-related pumping would be largely limited to the confined area of the N-Aquifer where aquifer storage coefficients are small. Once the cone of depression reaches the unconfined portions of the aquifer where storage coefficients are orders of magnitude higher than in the confined aquifer, the spread of the cone of depression is significantly reduced. The monitored spring locations are within the unconfined portion of the aquifer and distant from the confined/unconfined boundary.

A total of 98 non-monitored springs and seeps are represented by drain cells in the PWCC model. Due to model limitations, not all drain cells that were used to simulate non-monitored springs produced a flow rate. Since flow is proportional to change in head, to evaluate any potential change in flow at these locations the model-predicted change in head (drawdown) due to mine-related pumping was determined.

Predicted effects on simulated water levels caused by mine-related pumping were noted even if no flow at the spring was modeled. Model predicted maximum impacts to non-monitored springs and seeps are given in **Table 3.7-20**, below.

Table 3.7-20 Maximum Impact at Non-Monitored Springs Due to Mine-Related Pumping, Proposed Action [1]

Group	Number of Springs in Model	Maximum Impact Due to Proposed Action Mine Pumping [1]
A	8	No head or flow change
B	3	-0.002 feet head change at 1 spring; no flow change
C	9	Head change -0.001 to -0.013 feet at 2 springs; no flow change
D	19	Head change -0.001 to -0.23 feet at 2 springs; -0.0005 gpm flow at 1 spring
E	11	Head change -0.002 to -0.019 feet at 2 springs; no flow change
F1	9	Head change -0.001 feet at 3 springs; -0.00003 gpm at 1 spring
G	3	Head change -0.01 to -0.009 feet at 2 springs; no flow change.
I	2	Head change -0.006; -0.0003 gpm at 1 spring

[1] No impacts would occur to springs within the model boundary that have zero head change and are not noted in the table.

A number of USGS ‘likely’ springs are located outside the PWCC model boundary, including those in Groups F2, H and J, as shown on **Figure 3.7-15**. Given the distance of these springs and seeps from the proposed KMC leasehold water supply wells, and the small head and flow change at closer springs within the model boundary (**Table 3.7-20**), impacts at these spring and seep locations is negligible.

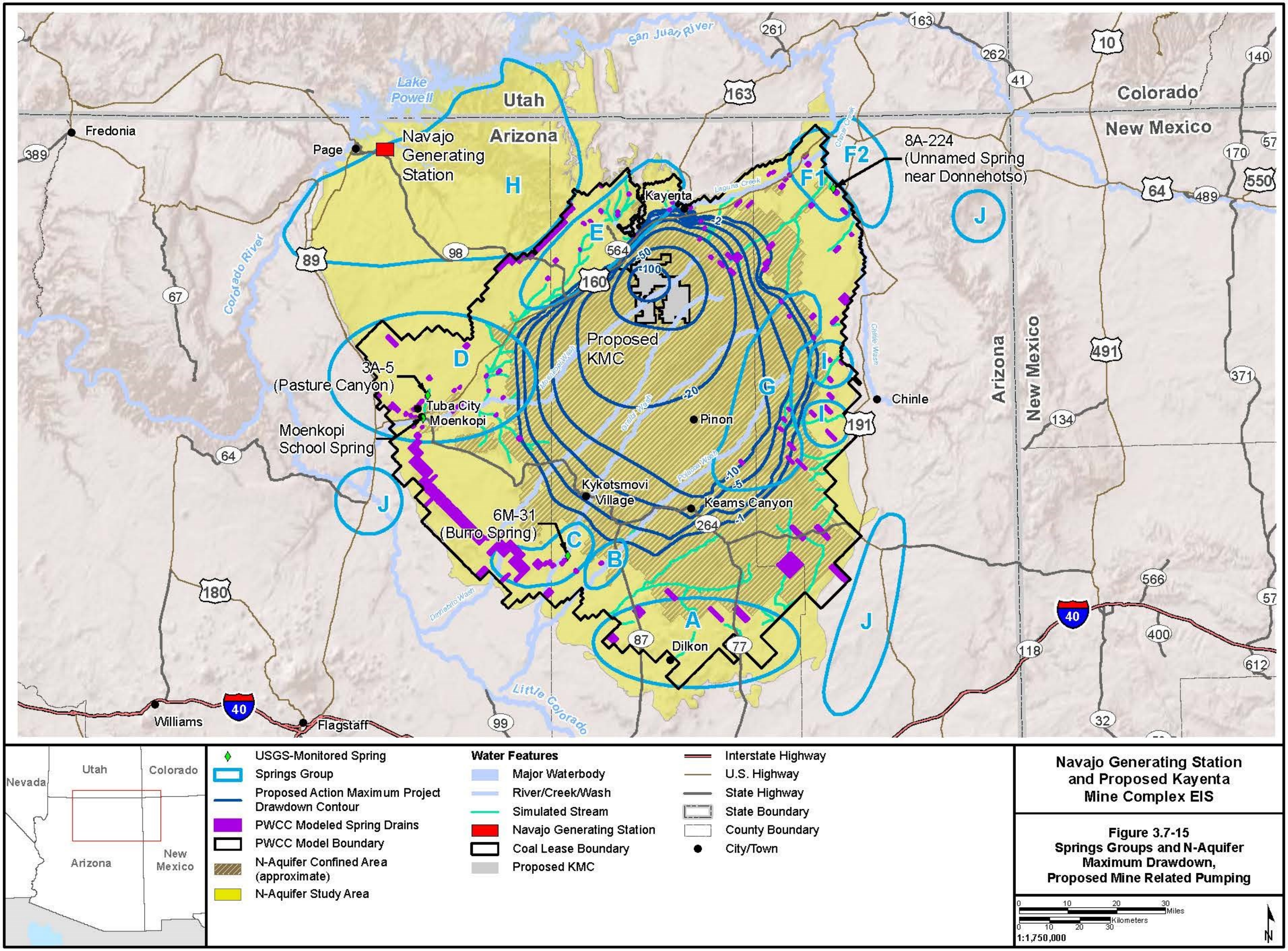

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Figure 3.7-15
Springs Groups and N-Aquifer Maximum Drawdown, Proposed Mine Related Pumping

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Head and/or flow change is limited to a small number of springs in each group and ranges between none to -0.23 feet and none to -0.06 gpm. As noted previously, these springs and seeps are in the unconfined portions of the N-Aquifer, and outside the 1.0 foot drawdown contour predicted for the Proposed Action mine-related pumping. Springs issuing from the D-Aquifer are isolated from proposed mine pumping and would not be affected by either Proposed Action operation. Because proposed mine-related pumping would generate either no or very small reductions in flows or water levels at D- and N-Aquifer springs and seeps, the potential impacts from either Proposed Action options would be negligible.

3.7.4.2.2.2 D-Aquifer Uses

- Scoping Concern: Pumping withdrawals from the N-Aquifer may be reduced by developing a new D-Aquifer water supply for mining and reclamation activities. This might improve the long-term sustainability of the N-Aquifer.

Effects of a D-Aquifer Partial Water Supply for the Proposed KMC, 3-Unit Operation	**Effects of a D-Aquifer Partial Water Supply for the Proposed KMC, 2-Unit Operation**
Low D-Aquifer productivity would limit its usefulness as a partial proposed KMC water supply. A large number of new wells and a new distribution infrastructure would be required; associated costs would be economically prohibitive. Pumping drawdowns would occur at windmills and some existing community wells. The reduction of anticipated combined N-Aquifer withdrawals would be minimal. Because of these factors, a partial D-Aquifer water supply at the proposed KMC is not considered further.	Factors and effects would be the same as those described for the 3-Unit Operation.

Based on project scoping input from agencies and the public, the EIS assessed the possibility of using D-Aquifer wells and groundwater withdrawals to provide part of the water supply at proposed KMC. Even if D-Aquifer wells were constructed, some N-Aquifer withdrawals would still be needed to support potable uses and sanitation. If developed, a new D-Aquifer supply also would need a separate distribution system due to its lower water quality. Evaluating a D-Aquifer partial supply for the EIS involved three major aspects: the technical capability of the D-Aquifer to provide adequate volumes of suitable water for mine uses, the economics involved in constructing a D-Aquifer wellfield, and the effects of such an effort on water resources.

<u>Technical Aspects</u>

Source location, adequate volume, and suitable water quality are the major technical considerations. Of course, the amount of water needed at the mine depends on its uses and the suitability of the source to meet those uses. As described in Section 3.7.3.1, the water quality of the D-Aquifer is marginal to unsuitable for potable or other uses (e.g., equipment washing) that occur at the mine. Therefore, existing N-Aquifer water would still be required to meet those uses at the mine, and to fulfill existing and future public water supply agreements for local tribal users. Additional acre-feet per year from the N-Aquifer would be required to supply the separate Many Mules project on the Navajo Nation from existing PWCC N-Aquifer well NAV2, but this is not part of the proposed demand for mine-related uses (Tetra Tech 2015a,b). This further demonstrates the need for maintaining an N-Aquifer water system.

Pumping demand at the proposed KMC during the period 2020 through 2044 is estimated to be approximately 1,200 acre-feet per year from the N-Aquifer. For purposes of this D-Aquifer substitute supply assessment, it is assumed that roughly 100 acre-feet/year of high-quality N-Aquifer water would still be needed for domestic and other uses at the mine, and to supply local public potable water needs. This is based on an estimate of high-quality potable water requirements for 516 mine employees and contractors, plus other facility uses requiring a similar supply, and an assumed 100 local tribal individuals that each use 100 gpd for domestic and miscellaneous uses from public water stands.

The average water quality of the D-Aquifer as reported in Section 3.7.3.1 would probably be suitable for dust suppression, fire suppression, or similar applications. Of the approximately 1,200 acre-feet per year estimated as pumping demand at the mine through 2044, there remain approximately 1,100 acre-feet per year of that projected demand that could be provided by lesser-quality D-Aquifer water. From 2044 to 2047, mine demand would drop to 500 acre-feet per year, of which it is estimated 100 acre-feet per year of potable water would continue to be needed. From 2048 and after, mine demand would drop further to about 100 acre-feet per year, most of which would consist of non-potable uses.

As part of the technical review, PWCC and its groundwater modeling contractor (Tetra Tech) were asked to simulate pumping from a hypothetical D-Aquifer wellfield at the mine, using known or estimated aquifer characteristics (e.g., depth, hydraulic conductivity, transmissivity). Results of this effort were carried forward into this assessment.

Because of limited data on water-level responses to D-Aquifer pumping in the locale, there are uncertainties in the hydraulic conductivity and storage properties for the D-Aquifer. As a result, there are uncertainties in the model predictions of water-level changes in the D-Aquifer from a pumping scenario. Based on limited testing from the 1960s, compared to more recent model calibrations, the model may over-predict the productivity of the hypothetical wells. The scenario investigated used the estimated well productivity based on the modeling work. However, because of the lack of information, there is a significant question about the ability of the D-Aquifer to provide the needed water (Tetra Tech 2015a,b).

In a hypothetical four-well D-Aquifer supply field, where all four wells would be built and operating in 2020, modeling results indicated the following:

- Well D2 (located at NAV2) could produce about 230 acre-feet per year initially, but would drop to about 210 acre-feet per year in 2044;
- Well D6 (located at NAV6) could produce 300 acre-feet per year for about five years, but would drop to about 240 acre-feet per year in 2044;
- Well D8 (located at NAV8) could initially produce about 220 acre-feet per year, decreasing to about 205 acre-feet per year in 2044; and
- A simulated well near the J28 coal resource area could produce about 240 acre-feet per year initially, but would drop to about 150 acre-feet per year in 2044.

Results from this exercise indicate that four D-Aquifer wells initially could produce about 990 acre-feet per year. In the year 2033, about halfway through the proposed major pumping duration, production from four D-Aquifer wells would drop to about 840 acre-feet per year. By 2040 about 810 acre-feet per year could be produced. These are insufficient supplies for the mine needs of about 1,100 acre-feet per year. Also, these results are based on the significantly more productive model inputs, compared to those indicated by limited testing in the 1960s. The D-Aquifer could be less productive than inputs used in modeling. As a result, anywhere between 5 to 10 (or more) D-Aquifer wells would be needed to meet estimated non-potable demands at the mine until 2044. As mentioned previously, from 2044 to 2047, mine demand would drop to 500 acre-feet per year. In 2048 and after, mine demand would drop further to about 100 acre-feet per year. These lower demands would reduce the number of D-Aquifer wells needed after 2044, approximately 25 years after the start of the Proposed Action.

Economic Aspects

Assuming the studies determine there would be sufficient volumes of D-Aquifer water that could meet the non-potable needs of the proposed KMC, and the impacts from such pumping were found to be acceptable, the associated costs to develop each production well is estimated to be about $1.1 million. This is a rough estimate based upon an itemized 2007 cost estimate to construct, test, and plumb out an adequate N-Aquifer supply well on Black Mesa, which was approximately $1.3 million (John 2016).). Based on this, an estimated cost to construct, test, and plumb out a shallower D-Aquifer supply well in the locale would be approximately $976,000 in 2007 dollars ($1.13 million in 2016 dollars). Cost changes since then would increase that estimate. A total estimated cost for five to ten D-Aquifer wells would range from roughly $5.5 million to $11 million in 2016 dollars. Substantial additional costs would be incurred by an independent infrastructure that would be required to keep D-Aquifer water separate from potable N-Aquifer supplies. Operation, maintenance, and testing costs also would be incurred, but could be offset somewhat by reduced activities at existing N-Aquifer wells. However, the N-Aquifer distribution system would still need to be operated and maintained, and pursuant to existing lease terms PWCC would be required to continue exercising (pumping) the N-Aquifer wells periodically to maintain their long-term operational viability.

Prior to being able to make any decision regarding use of D-Aquifer water to meet the non-potable water needs of the proposed KMC, extensive investigations would need to be conducted to provide better estimates of available volumes and pumping impacts from the operation of a proposed D-Aquifer well field, to meet the non-potable uses of the proposed KMC. These would entail drilling and pump testing a number of monitoring wells, and additional modeling using the pump test results. These investigations could take up to a year to complete. Assuming the results of these investigations indicated sufficient water could be provided by a D-Aquifer non-potable water supply system, additional environmental compliance would be required prior to final design and construction of a D-Aquifer wellfield and delivery system. This environmental compliance process could add another 0.5 to 1.5 years to the front end of wellfield development, at an estimated cost of $50,000 to $300,000.

If a D-Aquifer wellfield was in operation by the Year 2020, it would be in service for approximately 25 years. Under such highly conjectural circumstances, approximately 27,500 acre-feet of N-Aquifer water would be conserved through the Year 2044 by substituting D-Aquifer water for non-potable uses at proposed KMC. This assumes a substitution rate of 1,100 acre-feet annually. Given all the unknowns and due to fiscal considerations, however, it is more likely that the entire wellfield would not be in service by the Year 2020 and some or most of the period between 2020 and 2044 (when most pumping would occur) would have elapsed. In those conditions, the amount of N-Aquifer water conserved during the Proposed Action would be less, since N-Aquifer pumping would still be needed while the D-Aquifer wells were being built.

Resulting Effects

Using inputs and results from modeling, a D-Aquifer wellfield at the mine would create aquifer drawdown (water level declines in D-Aquifer wells) primarily in and near the coal leasehold. These results are based on the D-Aquifer characteristics used in modeling, which may be over-optimistic. Uncertainties exist regarding D-Aquifer hydraulic characteristics and productivity D-Aquifer drawdowns of approximately 50 to 100 feet were simulated in the coal lease area by the end of 2044, and would continue into 2057. These contours would be generally concentric, centering around the northwestern part of the KMC. By 2044, a roughly similar concentric 10-foot drawdown contour would extend in the aquifer past Forest Lake, and a 1-foot decline in D-Aquifer well water levels would extend to Pinon, Kits'illie and Chilchinbeto. Simulations indicated that declines in D-Aquifer water levels would increase to roughly 15 to 20 feet at Forest Lake at the end of 2057, but would remain at about 1 foot at Pinon, Hard Rock, or other communities. By the end of 2110, water level recovery in D-Aquifer wells would leave a small remnant of ten-foot decline at the south end of the coal lease area, with less at Forest Lake. Approximately 1 foot of drawdown would extend to Hard Rock, Pinon, Kits'illie, and Chilchinbeto (Tetra

Tech 2015a). Under a D-Aquifer pumping scenario, resulting N-Aquifer drawdowns would be less than under the Proposed Action: approximately one foot in the vicinity of the coal leases, Forest Lake, and Chilchinbeto in 2044 and 2057.

Windmills and community wells sourced from the D-Aquifer between the coal leases and communities such as Hard Rock, Pinon, Forest Lake, and Chilchinbeto would be affected by these various water level declines. If a substantial part of the community well at Forest Lake is open to the D-Aquifer as suspected, then some drawdown would occur in that well. With Proposed Action pumping, some declines in community well productivity are predicted to occur at Kayenta, Low Mountain, and Spider Mound in approximately 2095 to 2016 (Tetra Tech 2015a). These locations would not be affected by D-Aquifer pumping. Livestock wells would be affected by D-Aquifer drawdowns of 50 to 100 feet within or near the coal leasehold (Tetra Tech 2015a). Livestock wells would be affected by about 20 feet of drawdown south of the leasehold to near Forest Lake, and for 2 to 4 miles outside the north, east, and west leasehold perimeters.

Simulated effects on N-Aquifer springs and streamflows indicate no discernible differences between the Proposed Action (N-Aquifer) pumping at proposed KMC and a substitute D-Aquifer supply (Tetra Tech 2015a). There would be no difference between D-Aquifer pumping and proposed N-Aquifer pumping with respect to effects on baseflows in major channels such as Moenkopi Wash, Dinnebito Wash, Begashibito Wash, and others. Similar results also would occur at N-Aquifer springs. There are few, if any, D-Aquifer springs within the anticipated drawdown extent of either pumping scenario; therefore, spring effects would be negligible to minor.

After 2005, recent PWCC pumping has represented approximately 30 percent of the total combined N-Aquifer pumping. During the Proposed Action, mine-related N-Aquifer pumping would comprise continually declining proportions of the anticipated total annual demand on the N-Aquifer. The total projected N-Aquifer pumping volume for the Proposed Action is predicted to be approximately 32,500 acre-feet, or about 3 percent of the total anticipated 2020 to 2110 cumulative pumping from the N-Aquifer (including the mine and estimated community demands). Mine-related N-Aquifer withdrawals would comprise approximately 12 percent of total anticipated cumulative pumping from 2020 through 2057, when proposed PWCC pumping would cease. Thus, the benefit of reducing pumping from the N-Aquifer by using water pumped from D-Aquifer wells would be limited and would not warrant use of the D-Aquifer as a substitute water supply.

Implementing a D-Aquifer supply scenario at proposed KMC would have significant impacts on economic factors related to either Proposed Action options. At the same time, benefits to the N-Aquifer would be limited, given that a number of years or decades would be needed to complete a D-Aquifer wellfield compared to the timeframe of the Proposed Action. Over time, proposed mine-related pumping would be a diminishing factor compared to other N-Aquifer withdrawals. Because of these aspects, a substitute D-Aquifer water supply at proposed KMC is not further considered in the EIS.

3.7.4.2.2.3 Wepo Aquifer Water Levels, Water Quality, and Uses

- Scoping Concern: Mine pit development and reclamation could create groundwater drawdown in the Wepo Formation and reduce supplies to wells, springs, and alluvium.

Impacts from Reduced Wepo Formation Groundwater Quantities within the Coal Lease Areas from Mining Activities, 3-Unit Operation	Impacts from Reduced Wepo Formation Groundwater Quantities within the Coal Lease Areas from Mining Activities, 2-Unit Operation
Negligible effects to well water levels or overall groundwater quantities in the Wepo Formation or connected springs and alluvium would occur. PWCC would continue to mitigate impacts that may occur.	Effects would be the same as those described for the 3-Unit Operation.

Recent water levels in Wepo Formation monitoring wells indicate the greatest water level changes (over 4 feet during the 2010 through 2014 period) are recorded in six wells: WEPO41, WEPO43R, WEPO44, WEPO52, WEPO53, and WEPO67(**Appendix WR-5**, **Table WR-5.1**). For the period 2010 through 2014, the greatest individual water level changes occur at WEPO52, which had a maximum rise of 2.0 feet, and a maximum decline of 5.6 feet. The other five listed wells had water level rises between about 1 to 2 feet, and declines between about 1 to 4 feet during the period. Water level changes were smaller in the other 17 Wepo wells with complete annual data in the table. Generally these smaller changes were less than about 0.7 feet rising or falling over the 5-year period. All water level comparisons are based on the deepest recorded levels each year, which is a conservative approach. These variable water level conditions (rises and declines) would continue in the Wepo Aquifer under a Proposed Action option, as further discussed below.

Early data for depths to water in the Wepo Formation are recorded for wells WEPO49, 54, 65, 66, and 67 during the period 1980 to 1984. In 2014 by comparison, the water level in WEPO49 was 8.4 feet higher than its greatest level during the 1980-1984 period, and it was 4.0 feet higher than its shallowest recorded level. Recent water levels at WEPO54 remained approximately at the middle of their range from the early baseline (1980 to 1984) period. At WEPO65, recent (2010 through 2014) levels approximated the deepest value for most of the 5-year period, but then declined an additional 1.4 feet in 2014. Recent levels in WEPO66 were well within their historic range from 1980 to 1984. At WEPO67, recent levels remained 25 to 30 feet shallower than their deepest level in 1980 to 1984, but were somewhat deeper than the middle of the recorded historic range. Future mining may lower water levels in adjacent Wepo wells, as has occurred in the past at wells such as WEPO62 (68.6 feet deeper) and WEPO53 (16.1 feet deeper) (PWCC 2012 et seq.). However, at other wells (e.g., WEPO40, 42, 43R, and 44), adjacent mining resulted in little or no effects to water levels. Groundwater has been rising in these four wells since 2010, and did not decline from historic background levels.

In the Proposed Action option, groundwater drawdown in the Wepo Formation would depend on pit configurations in relation to water-bearing zones, as it has in the past. Based on the data described above, variable fluctuations would occur in Wepo Formation water levels over the life of either Proposed Action options. Water levels would decline at a few wells, remain within their former ranges at most wells, and rise at others. These conditions generally reflect the isolated, perched water-bearing zones characteristic of the formation, and its responsiveness to variations in climate and recharge. From existing data, it is likely that most Wepo wells would maintain water levels within their historic ranges under a Proposed Action option. Based on the isolated, limited lateral extents of water-bearing zones in the Wepo Formation, any drawdown effects that may occur would probably extend less than 1 mile or so from proposed mining. If these impacts occurred, they would be of a minor, highly localized nature due to formation characteristics and the natural variability typical of Wepo Formation water levels.

There are approximately 18 existing privately used local wells within the coal lease areas or in the general area (PWCC 2012 et seq.). Some of these do not appear to be in use. Since the Wepo Formation is not very productive, construction information gathered by PWCC indicates that most of these wells are supplied from sources other than the Wepo Formation, such as alluvium or the Toreva or Dakota formations (PWCC 2012 et seq.). Six Wepo wells remain in or within about 3 miles of the leasehold (4K-380, 4K-389, 4T-405, 4T-512, 8A-PHS-15, and W00236110-D.24). Historically, other wells (8T-506, a Wepo well, and 4T-403, a Toreva well) were previously removed during the course of mining. Existing well 4T-404 (a Toreva well) would be removed during mining in the J-19 area. PWCC is required to repair or replace water supplies in accordance with Surface Mining Control and Reclamation Act regulations. Because of this, combined with the limited extent of potential mine-related drawdown effects and the natural variation of Wepo Formation water levels, no impacts to existing Wepo or Toreva water supplies would occur from either Proposed Action options.

The variation in Wepo Formation water levels is expected to contribute to variable springflows and alluvial water levels. With respect to shallow spring sources, flows at some Wepo springs in the leasehold that are in or near alluvial channels or near active mining have maintained their historical flows (e.g., Natural Spring [NSPG]22, NSPG61; **Appendix WR-3, Figure WR-3.1**), and a new spring (NSPG64) developed along lower Coal Mine Wash. Natural Springs are those determined to be a pre-existing spring (i.e., noted prior to the onset of mining activity), or not connected in any way to either mining or any other human activity. Flows at another spring (NSPG21) went dry. Springs in alluvial settings in the former Black Mesa Mine area (NSPG561, 562, 563) have maintained flows typical of their ranges measured since 2007. These interactions and their results would continue under a Proposed Action option. Wepo groundwater contributions to alluvial water levels were briefly mentioned in the previous alluvial aquifer discussion. Alluvial water levels from 2010 through 2014 indicate that conditions at background alluvial wells varied from year-to-year, and changes (rises or declines) were inconsistent between wells. An overall decline in water levels at background alluvial wells occurred during the period; effects that were primarily driven by drought and not by mining. To re-iterate, monitoring data indicate that within the coal lease areas, local alluvial water levels may rise or fall during such overall declines. Locally, these variations would be affected by the anticipated variable changes in Wepo well water levels, and importantly, changes in precipitation.

While minor local reductions may occur, little or no overall impacts to hydrologic conditions or water use in the leasehold would occur from mining impacts to Wepo Aquifer groundwater quantities under either Proposed Action options. Overall mine-related impacts would be negligible This conclusion is based on the variable but generally limited amount of drawdown in Wepo monitoring wells, the generally small flows from monitored springs, and the comparatively few wells that are supplied by the Wepo Formation or connected alluvial groundwater. As mentioned, PWCC has mitigated impacts to these resources in the past with replacement water supplies from wells or ponds. Under a Proposed Action option, PWCC would continue to offset any impacts to designated and foreseeable water uses through water supply replacement within the proposed KMC, in accordance with federal regulations (OSMRE 2011a).

- Scoping Concern: Water quality in the Wepo Formation and hydrologically connected springs and baseflows could be reduced by mining and reclamation activities.

Impacts of Reduced Wepo Formation Groundwater Quality from Mining and Reclamation Activities, 3-Unit Operation	Impacts of Reduced Wepo Formation Groundwater Quality from Mining and Reclamation Activities, 2-Unit Operation
In addition to natural processes, mining and reclamation would continue to locally elevate TDS and sulfate concentrations in Wepo Formation groundwater and in hydrologically connected springs and stream baseflows. These would be localized, minor impacts. Ongoing PWCC mitigation in the form of permanent ponds and impoundments would maintain existing local water uses consistent with present conditions.	Potential impacts would be the same as those described for the 3-Unit Operation.

Background water quality in the Wepo Formation is monitored at wells WEPO55, 56, 57, 59, 61, 65, 67, 69 (**Appendix WR-5, Figure WR-5.1**). All but the last three are in the former Black Mesa Mine area, where no further mining is proposed. Recent water quality characteristics are summarized for these background wells in **Appendix WR-5**, and were briefly described in the respective Affected Environment discussion. Background trace element concentrations were low except for boron, which remained well within the livestock watering benchmark. Comparisons between Wepo Formation wells indicate that trace elements remained at low levels in background Wepo wells as well as those that may be affected by mining. Because of this, trace element impacts from mining activities would not occur or would be negligible in Wepo Formation water quality under either Proposed Action options.

In general, TDS and sulfate concentrations typically increased at Wepo wells that were likely affected by mining activities. It should be noted that these increases, although they can represent large percentage changes from typical sulfate and TDS values at background wells, still remain within the recommended livestock watering values used as benchmarks. For example, for all background wells, recent median sulfate and TDS concentrations (**Appendix WR-5, Table WR-5.7**) are 168 and 862 mg/L, respectively. In the northwest mining locale, recent median values are 760 and 1,370 mg/L for sulfate and TDS, respectively (**Appendix WR-5, Table WR-5.3**). Recent median sulfate and TDS values in the northeast mining locale are 513 and 1,665 mg/L, respectively (**Appendix WR-5, Table WR-5.4**). Recent median values in the former Black Mesa mine area are 475 and 1,505 mg/L for sulfate and TDS, respectively (**Appendix WR-5, Table WR-5.6**). Long-term results are similar: **Appendix WR-5, Table WR-5.8** shows similar values for background wells, and **Tables WR-5.9, WR-5.10,** and **WR-5.12** indicate that long-term conditions are similar to recent conditions in the other areas.

Sulfate and TDS conditions along Dinnebito Wash warranted additional review. In the J-21 mine area along Dinnebito Wash, TDS values at WEPO66 and 68 averaged 3,213 mg/L, and sulfate values averaged 1,631 mg/L. The background TDS values in the area ranged from 1,180 to 1,680 mg/L, less than half the average of WEPO66 and 68 near mining. Sulfate concentrations were very low at the background wells in the area, whereas bicarbonate values were much higher. On further review, the TDS and sulfate values differ substantially between WEPO66 and WEPO 68, with much lower concentrations in the latter well approximating background conditions. So the possibility is that mining affects WEPO66, but not WEPO68. Based on Wepo Formation well tests, transit times for potential drainage from the J21 pit to WEPO66 would vary, from over 65 years up to over 800 years (PWCC 2014). Since the pit has been active since 1985 (approximately 32 years), it is unlikely that mining activity has created the elevated sulfate and TDS values in WEPO66. The well is in an undisturbed locale above the influence of alluvial contributions. The most likely source of elevated values in WEPO66 is natural recharge through the porous scoria along Dinnebito Wash, accompanied by drainage through underlying Wepo shales and coal seams.

In addition to the data from wells, Wepo Formation springs that are physically separated from mining activities (e.g., NSPG111, 147) also reflect very high TDS and sulfate concentrations as natural background conditions, as mentioned previously under "*Spring Flow Quality*" in the Affected Environment discussion and tabulated in **Appendix WR-3**. It is likely that natural, near-surface weathering and sediment accumulations from various Wepo Formation lithologies contribute to some of these conditions on upper Black Mesa overall. In particular, weathering of naturally present gypsum in geologic materials contributes to these effects.

Mining activities would expose new chemically reactive particle surfaces during pit excavation and reclamation, when overburden and interburden rocks would be fractured into smaller sizes and mixed. During near-surface wetting and drying, these materials would undergo additional weathering and contribute readily soluble constituents to runoff, seepage, and stored groundwater in mined areas. Based on PWCC information, sufficient carbonate materials and alkaline salts are available in spoil materials to neutralize acid production and drainage resulting from sulfide oxidation (PWCC 2012 et seq.). Consistent with this, very few acid pH results are present in any monitoring data. In this process, where carbonates react to neutralize potentially acid-forming products, additional alkaline salts enter into solution and consequently elevate TDS levels (PWCC 2012 et seq.).

The locations and timing for these effects to appear in deeper water-bearing zones within mine spoils is unknown, and probably varies with site-specific flow gradients, recharge and geologic conditions, and climate patterns. For example, in the N-1 mining area, spoil monitoring wells SPL207 and 209 had median TDS values of 6,100 and 7,805 mg/L, respectively, and median sulfate values of 3,700 and 4,885 mg/L, respectively. In contrast, monitoring well WEPO40 adjacent to the N-1 mine area had typical TDS values of about 1,650 mg/L, and typical sulfate values of about 480 mg/L. While these recent WEPO40 concentrations are greater than typical background values, they are much less than the spoil values. Since the N-1 area was mined and reclaimed between 1974 and 1984, mining effects on groundwater quality in the deeper water-bearing spoil may not materialize. If they ever do, it may take more than a few decades. The extent of groundwater quality impacts, if they occur, would be limited by the complex geologic nature of the Wepo Formation as described in the Affected Environment section and **Appendix WR-5**. The generally isolated nature of Wepo Formation water-bearing zones would prevent effects from occurring much beyond the leasehold. Because of this, impacts to Wepo Formation water quality would be minor under either Proposed Action options. In addition to the other constituents, the vast majority of the Wepo monitoring data for sulfate and TDS remain well within recommended livestock comparison benchmarks. Thus, although water quality effects from mining are anticipated in the Wepo aquifer, they would be comparatively minor impacts. They would have limited extent due to the discontinuous nature of water-bearing zones in the formation (**Appendix WR-5**), and would be limited to separate locations within or adjacent to the leasehold. Further discussions of water quality effects in springs and alluvial groundwater are presented in respective sub-sections below.

3.7.4.2.2.4 Alluvial Aquifers – Water Levels, Water Quality, and Uses

- Scoping Concern: The quantity of groundwater in alluvial deposits could be reduced by mining activities such as pit development, water management, and reclamation. In turn, that may affect existing uses such as livestock watering or riparian habitat.

Impacts from Reduced Alluvial Groundwater Quantities within the Coal Lease Areas from Mining Activities, 3-Unit Operation	Impacts from Reduced Alluvial Groundwater Quantities within the Coal Lease Areas from Mining Activities, 2-Unit Operation
Impacts to water levels or overall groundwater quantities in alluvial deposits would be none or negligible.	Impacts to water levels or overall groundwater quantities in alluvial deposits would be none or negligible.

The greatest water level changes (over 5 feet during the recent period of 2010 through 2014) are recorded in eight wells: ALUV 19, ALUV83, ALUV87, ALUV89R, ALUV98R, ALUV172, ALUV181, and ALUV197 (**Appendix WR-4, Table WR-4.1**). For this recent period, the greatest water level changes occur at ALUV172, which had a maximum rise of 2.0 feet, and a maximum decline of 4.2 feet. The other seven listed wells had water level rises generally between about 1.5 to 3.0 feet, and declines generally between 1.5 to 3.5 feet during the period. Water level changes were smaller in the other 17 alluvial wells with complete annual data in the table. All water level comparisons are based on the deepest recorded levels each year, which is a conservative approach.

Long-term background alluvial wells include ALUV69, ALUV87, and ALUV108R (**Appendix WR-4**, **Figure WR-4.1**). These have data reports through 2014. An earlier background alluvial well (ALUV77) was idled in 2002. Water levels from the 2010 through 2014 period indicate that at these wells, background conditions varied from year-to-year, and changes (rises or declines) were inconsistent between wells. Overall however, depths to water generally increased by 1.3 feet (a water level <u>*decline*</u>) over the period at ALUV69 upstream on Yellow Water Canyon Wash, by 4.4 feet at ALUV87 on the mainstem of Moenkopi Wash, and by 1.1 feet at ALUV108R on Dinnebito Wash. These conditions probably result from drought. Drought conditions are explained more in the climate section (Section 3.2) of the EIS, and previously in Section 3.7.3.1, Regional Overview.

Downstream on Yellow Water Canyon Wash, water levels also generally declined over the 2010-2104 period, similarly to background well ALUV69. Water levels, while generally declining, showed no consistent changes year-to-year or from well-to-well. There were no consistent year-to-year rises or declines associated with the extent of mining activity along the wash. Along Coal Mine Wash over the same period, alluvial water levels fluctuated between rises and declines.

Changes in alluvial water levels along Moenkopi Wash and Dinnebito Wash were similar to those described above for Yellow Water Canyon Wash and Coal Mine Wash. Upstream on Moenkopi Wash, background well ALUV87 had a net water level decline of 4.4 feet over the 2010 through 2014 period. Other wells along the wash generally had rising water levels of about 1 or 2 feet. On Dinnebito Wash, the levels in background well ALUV108R declined a net 1.1 feet; levels in most other wells rose on the order of 0.5 feet.

These overall conditions are consistent with earlier analyses (OSMRE 2011a) that indicated greater declines in alluvial inflows (declining upstream water levels) compared to outflows (downstream rises or mixed fluctuations) across the coal lease areas. Within the coal lease areas, alluvial channels have not deepened to elevations where they intercept the Toreva Formation. Thus, groundwater recharging the alluvium mainly comes from the Wepo Formation (OSMRE 2011a). Other recharge to the alluvium comes from precipitation and infiltration of runoff. The spatial and temporal variations of precipitation, infiltrating runoff, and Wepo Formation contributions create alluvial water levels that vary. Seepage below some impoundments (e.g., J7DAM) prolongs water contributions to alluvial deposits. Water quality aspects of seepage are discussed below. Drought influences all of these factors. Monitoring data indicate that within the coal lease areas, local alluvial water levels may rise or fall during overall declines in background water levels. All of these conditions would continue under either the Proposed Action 3-Unit Operation or 2-Unit Operation.

These results are not likely to affect existing alluvial groundwater uses in the lease area locale. Historically, attempts were made to develop alluvial water resources in the coal lease areas and nearby. However, none of the locations have been utilized or maintained for several decades (OSMRE 2011a). Continued access to potable public water supplies and surface water impoundments make development of the saturated alluvium less attractive for livestock watering or domestic uses. Riparian habitats would continue to be supported by alluvial groundwater as they have been over the past 5 years or more, based on the variability of alluvial water levels and generally smaller declines downstream than in upstream background wells.

Because of these conditions, impacts to alluvial groundwater quantities and availability within and downstream of the coal lease areas would be none or negligible under either Proposed Action option.

- Scoping Concern: The quality of groundwater in alluvial deposits, and its ability to support existing uses such as livestock watering or riparian habitat, could be reduced by mining activities such as pit development, water management, and reclamation.

Impacts from Reduced Alluvial Groundwater Quality within the Coal Lease Areas from Mining Activities, 3-Unit Operation	**Impacts from Reduced Alluvial Groundwater Quality within the Coal Lease Areas from Mining Activities, 2-Unit Operation**
Trace element impacts would not occur in alluvial groundwater quality. Along with natural background processes, mining would continue to contribute to elevated TDS and sulfate concentrations in alluvial groundwater at some locations. These would be negligible to minor, isolated impacts. No adverse effects to existing water uses are anticipated from continuing variations in alluvial groundwater quality.	Effects would be the same as described for the 3-Unit Operation.

Water quality in alluvial wells has been monitored over time as described in the Affected Environment section and summarized in both recent and long-term tables in **Appendix WR-4**. As previously mentioned (see the alluvial groundwater Affected Environment discussion), it should be noted that surface water quality standards do not apply to groundwater in the alluvium or other aquifers. The wildlife habitat and livestock watering criteria for surface water are simply used here to provide a basis for describing existing conditions in shallower groundwater zones, and as benchmarks for comparing the potential direct, indirect, and cumulative effects of a Proposed Action option or alternatives on water quality. This is consistent with earlier agency approaches (OSMRE 2011b) and recommendations, as well as PWCC annual hydrologic reports. (Drinking water standards are employed for the same purpose for the N-Aquifer.) Therefore, in groundwater discussions, concentrations that are greater than the wildlife habitat or livestock watering criteria are not regulatory exceedances in the same context as surface water evaluations. They are only comparisons to selected reference values.

Aluminum is generally not detected in alluvial groundwater monitoring, either in background or affected locations. When detected, most alluvial groundwater has dissolved aluminum values below the NNEPA total chronic criterion for wildlife habitat (0.087 mg/L); the dissolved fraction is the most biologically available. The selenium criterion for livestock watering (0.05 mg/L) was not surpassed in alluvial groundwater. Where selenium was detected, dissolved concentrations were usually greater than the chronic wildlife habitat criterion (0.002 mg/L). However, this also occurred in upstream background wells ALUV69 and ALVU87, which are unaffected by mining.

Copper and lead were rarely detected in alluvial groundwater monitoring at upstream stations (**Appendix WR-4, Tables WR-4.9** and **WR-4.11**). They also were rarely detected downstream on Moenkopi Wash **Appendix WR-4, Table WR-4.12**) or Dinnebito Wash (**Appendix WR-4, Table WR-4.10**). Lead was detected in 6 percent of downstream samples on Dinnebito Wash, and exceeded standards in one sample out of 64. Vanadium and chromium were rarely detected in alluvial groundwater monitoring at upstream or downstream stations (**Appendix WR-4, Tables WR-4.9** through **WR-4.12**). There were no concentrations in excess of surface water standards for these two constituents. For these four trace elements (copper, lead, vanadium, chromium), these alluvial water quality characteristics would likely continue under either Proposed Action options.

Other trace elements, such as arsenic, cadmium, mercury, and zinc, are either not detected in alluvial groundwater samples or occur at low levels (**Appendix WR-4**). Based on these conditions, no impacts would occur and no existing uses would be affected by trace element constituents by a Proposed Action option.

Sulfate and TDS concentrations also were compared between background conditions and wells likely affected by mining. In background alluvial wells (ALUV69, ALUV87, and ALVU108R), TDS concentrations ranged from 2,880 to 9,900 mg/L during the period 2010 through 2014. Sulfate concentrations also were elevated at all three background wells, ranging between about 1,500 to 6,300 mg/L. As mentioned, these elevated background concentrations reflect alluvial aquifer water quality that has not been affected by mining activity. In comparison to recommended livestock watering concentrations (which are not standards), these background concentrations are elevated (**Appendix WR-4** tables). Because of these levels, TDS and sulfates are the primary constituents used for further alluvial water quality comparisons and impact assessments.

In Yellow Water Canyon Wash and Coal Mine Wash, median alluvial sulfate and TDS concentrations varied between wells, but generally increased notably downstream across the lease areas in both washes. Near the N-1 mine area, nearby alluvial groundwater TDS concentrations at wells ALUV80R and 193 were elevated, with median values of 4,095 and 6,140 mg/L, respectively. Median sulfate values at ALUV80R and 193 also were elevated, at 2,305 and 3,970 mg/L, respectively. In contrast, within the Moenkopi Wash channel alluvium, median concentrations of these constituents declined downstream from high values at ALUV87 upstream of mining. In part, this may be due to the increasing undisturbed watershed area downstream of Reed Valley Wash.

Along Reed Valley Wash, water quality also varied, but recent median TDS and sulfate concentrations generally declined in samples from upstream to downstream. In the Red Peak Valley Wash area, the median sulfate and TDS concentrations in downstream samples at ALUV172 were approximately 2.5 times those of other alluvial wells on upstream tributaries. Elevated concentrations of these constituents also occurred at well ALUV29, most likely a result from J7DAM seepage. Alluvial water quality varied along Dinnebito Wash, where most downstream wells had median TDS and sulfate concentrations similar to background well ALUV87 upstream. As seen in **Appendix WR-4** tables sulfate and TDS concentrations in alluvial groundwater often surpassed recommended concentrations for livestock watering at alluvial monitoring wells near mining. However, these conditions also pertain to background wells. Statistical trends summarized for 16 alluvial wells from 1986 through 2014 (PWCC 2014) indicate that five had no trends for TDS, five had positive (increasing) trends, and six had negative (decreasing) trends). On Dinnebito Wash, background well ALUV108R had an increasing TDS trend, as did ALUV168, which is upstream of most mining activities. For sulfates, four of the 16 wells had no trend, four had increasing trends, and eight had decreasing trends (PWCC 2014). Background well ALUV108R had a decreasing sulfate trend, whereas well ALUV168 had an increasing trend (PWCC 2014). These mixed results are likely to continue under either Proposed Action options.

As noted previously, the Wepo Formation interacts with groundwater in the alluvial aquifer. Springflows and alluvial groundwater may exhibit more rapid geochemical processes at shallower depths, as reflected in background conditions noted at springs NSPG111 and NSPG147 (see the Wepo Aquifer water quality discussion above). Mining effects can locally intensify conditions created by natural background processes, and may have caused increases in some water quality constituents including TDS and sulfate in the leasehold. In addition to transport in baseflows from the Wepo Formation and alluvium, dissolved constituents are left along streams and toeslopes during runoff recessions, along with total constituents deposited with sediments and organic matter. These processes also occur in undisturbed watersheds elsewhere on Black Mesa.

In summary, sulfate and TDS concentrations are elevated in the background alluvial groundwater samples upstream of the mine areas, and along the washes downstream through the lease areas. Along some washes, these concentrations increase downstream through the mine areas; along others, they decrease. Background soil and geologic conditions, mining and water management, seeps and springs, and salt-adapted vegetation affect these variations. A mix of other flow sources (precipitation runoff, mine water management, and Wepo Formation drainage) would continue to influence alluvial water conditions. Because of these factors, negligible to minor, localized groundwater quality impacts are likely to occur at some alluvial aquifer locations within or adjacent to the leasehold. As mentioned previously, PWCC mitigates effects to local water supplies and their uses by developing replacement water supplies. This would avoid impacts to existing water uses during either Proposed Action options.

Since alluvial groundwater is generally not used for livestock watering, that use would not be affected by alluvial groundwater quality. In scattered locations where alluvial groundwater “daylights” to intermittent stream reaches, resulting water quality would periodically reflect some influence of alluvial drainage to the surface. These would be negligible to minor local water quality impacts which would generally not create effects on wildlife habitat uses.

3.7.4.2.2.5 Shallow Springs and Seeps

- Scoping Concern: The occurrence of seeps and springflows from shallow groundwater sources could be reduced in and near the coal leasehold by mining effects on groundwater in the alluvium and Wepo Formation.

Impacts to Flow at Shallow Springs and the Occurrence of Seeps, 3-Unit Operation	Impacts to Flow at Shallow Springs and the Occurrence of Seeps, 2-Unit Operation
Some minor, localized incremental reductions in spring flows and moisture at seeps would likely occur from mining. Minor effects would vary from one locale to another within and adjacent to the leasehold, and would occur within an over-riding trend of declining spring flows in the region due to drought. If the existing drought phase trends back to wetter conditions, springs and seeps would provide more flow or moisture than during recent existing conditions.	Potential impacts would be similar to those described for the 3-Unit Operation.

Shallow springs and seeps are those associated with the Wepo Aquifer and to a lesser degree, channel alluvium. These sources are at or relatively near the land surface, and are further discussed in following sub-sections. Springs and channel baseflows provided by deep groundwater sources were discussed previously, in relation to the N-Aquifer and potential pumping effects from the Proposed Action. Seeps also are associated with sedimentation structures, and their presence depends on runoff captured by the structure. Seeps also may be present naturally.

A number of springs are associated with the Wepo Formation in or near the coal lease areas, as described for the Affected Environment. Long-term flows from approximately 20 monitored springs are summarized in **Appendix WR-3**. Monitored springflows vary substantially over time and from place to place. During the period 2010 through 2014, flows at springs outside of alluvial channel beds either consistently declined, or were within historical ranges until 2014. By 2014, all springflows outside of alluvial channel beds had noticeably declined. This occurred at sites adjacent to mine pits, as well as at background sites separated from mining such as NSPG149 (Sand Spring), NSPG111, and NSPG147.

Changes in alluvial groundwater levels were discussed above. In general, there are recent overall declines in alluvial groundwater levels upstream of the leasehold, within it, and downstream. However, recent flows at springs in alluvial channels, such as NSPG91 in Coal Mine Wash, and others in Red Peak Valley Wash (NSPG561, 562, and 563 in the former Black Mesa Mine area), mimicked their historical flows.

Under either Proposed Action options, some shallow springs and seeps could be affected by surface mining activities such as pit excavations and backfills. There are likely to be continuing declines in springflows near mining under either the 3-Unit Operation or 2-Unit Operation. These effects would vary from one locale to another, depending on climate and recharge as well as local hydraulic gradients and connections. Declines in nearby isolated water-bearing zones in the Wepo Formation and hydraulically connected channel alluvium would result from mine pit development and associated drawdowns. Because of the connectivity to spring features, some incremental springflow reductions near pit activities would likely result from mining. These anticipated flow reductions would occur within an overriding trend of declining springflows at background locations and in the region overall, due to extended drought. Because of these factors and the restricted areas of influence, these would be minor highly localized impacts.

Under both the 3-Unit Operation and 2-Unit Operation, spring flows at NSPG94 and NSPG140 in the N9 coal resource area (**Appendix WR-3, Figure WR-3.1**) would be reduced through drawdown at the proposed mine expansion after 2019. NSPG140 typically has had little or no flow since the early 1980s, but has been known to flow up to 0.1 gpm at one time (**Appendix WR-3, Table WR-3.1**). Existing mining at N9 began in 2007, and it is likely that little or no additional drawdown impacts would occur at NSPG93 and NSPG95. Under the 3-Unit Operation, proposed mining would occur at the N10 coal resource area, approximately 0.7 mile upgradient of NSPG91 and adjacent to NSPG21. Flows could somewhat be reduced there; they ranged from about 0.5 to 1.6 gpm in the past 5 years at NSPG91. Flows at NSPG21 varied from 0 to 5 gpm in 2008, but typically there is no flow. Flows could somewhat be reduced at NSPG22 and NSPG97 near the N11 Extension coal resource area. In the J21-W coal resource area, NSPG191 would be removed by mining. By 2019, it will have already been affected by recent or planned mining there. No subsequent direct impacts to NSPG191 would occur under a Proposed Action option. Because of the factors and conditions described previously, these would be minor, highly localized impacts.

Similar impacts to springs would occur under the 2-Unit Operation, except that anticipated flow reductions at NSPG91 would be unlikely, due to the N10 area being excluded from mining under 2-Unit Operation.

- Scoping Concern: Groundwater quality at shallow springs and seeps could be reduced in and near the leasehold by mining activities.

Impacts to Water Quality at Shallow Springs and Seeps in and Near the Coal Leasehold, 3-Unit Operation	**Impacts to Water Quality at Shallow Springs and Seeps in and Near the Coal Leasehold, 2-Unit Operation**
Impacts to water quality at shallow-aquifer springs and seeps would be none to minor, and would be highly localized if they occur. An existing formal protocol for seep monitoring and management would continue to avoid or reduce water quality impacts at seeps. Impacts from seeps under this Proposed Action option would be none or negligible.	Potential impacts would be the same as those described for the 3-Unit Operation.

Water quality at most Wepo or alluvial aquifer springs is not anticipated to decline under either Proposed Action options. Springs emanating from reclaimed pit backfills also have been monitored, and are distinguished from natural or native springs (NSPG) by the label indicating a “spoil spring” (SSPG). A limited number of samples taken 5 years apart at SSPG150 indicate TDS and sulfate concentrations there are much less than those at background springs NSPG111, 147, and 92, which are distant from mining. Based on data, reclaimed pit backfills are not anticipated to adversely affect spring water quality.

At other monitored springs that could be affected by proposed mining activities, some already reflect elevated sulfate and TDS concentrations on the order of those at background locations such as NSPG111. These monitored springs include NSPG22 and NSPG140. Their water quality would not be affected by proposed mining. In addition, NSPG91 and NSPG191 have existing water quality similar to Wepo Formation groundwater in wells that are likely affected by mining. NSPG21 has water quality similar to Wepo wells believed not to be affected by mining. Water quality at these last three springs (NSPG91, 191, and 21) may be further reduced by proposed mining. In the recent past, NSPG91 has typically flowed, but NSPG21 and 191 typically have not been flowing. Historical average flows have been 0.55 to 3.11 gpm at the three sites. Because of their proximity to proposed mining, it is likely that negligible to minor localized water quality effects would occur at these three locations. For existing uses, permanent ponds would mitigate water quality impacts and provide more reliable water supply.

The occurrence of seeps, and formal plans to address impacts related to seeps, was described in the Affected Environment section. Additional seeps are likely to occur downstream of ponds and impoundments as these are built during either Proposed Action options. Other seeps would be removed as mining and reclamation proceed. Highly localized impacts to adjacent surface water quality may occur under either Proposed Action options. Since the USEPA and PWCC have instituted a formal seep monitoring and management plan, and an associated review protocol, those impacts that may occur at seeps would be identified and mitigated. As a result, future impacts to surface water quality at seeps would be none to negligible under either Proposed Action options.

3.7.4.2.2.6 Moenkopi and Dinnebito Washes, Streams

- Scoping Concern: Streamflows and related designated uses downstream along Moenkopi Wash or Dinnebito Wash could be reduced by water retained in additional ponds and impoundments at the proposed KMC.

Impacts from Additional Ponds or Impoundments at the Proposed KMC, 3-Unit Operation	Impacts from Additional Ponds or Impoundments at the Proposed KMC, 2-Unit Operation
Along Moenkopi Wash or Dinnebito Wash in and near the leasehold itself, during mining there would be moderate hydrologic shifts from estimated average channel flows being withheld as retention storage. These effects would decline after reclamation at the end of proposed mining. In addition, permanent ponds would mitigate impacts to existing designated water uses and improve local water availability near the mine area. Existing channel seepage losses, evapotranspiration, storm variability, and the ephemeral nature of flows prevent potential storage effects on the leasehold from extending far downstream.	Impacts would be similar to the 3-Unit Operation.

Temporary sediment ponds are important structures that help control runoff and surface water quality in the leasehold and nearby downstream channels. Along with other structures and management practices, they are designed, constructed, maintained, and reclaimed as needed to comply with regulatory programs. Surface water quantities would be affected in the coal leasehold by the increased extent of disturbed areas, and by the drainage and retention structures employed to manage runoff, sediment, and pit inflows. Greater runoff volumes, higher discharges during storms, and increased sediment yields would result from project components such as roads, storage yards, and the areas undergoing mining and reclamation. These potential impacts have long been recognized in regulatory programs and corresponding mine water management. In response, PWCC has designed, constructed, and maintained the surface water management system at former and existing facilities, and would do so for the proposed KMC. As noted in Chapter 1.0 (where existing and proposed facilities at the proposed KMC are described), the status and numbers of ponds and impoundments would change during the proposed Life-of-Mine. These changes are reflected in **Table 3.7-21** below. The locations and characteristics of permanent ponds and impoundments are determined through coordination with applicable agencies.

Table 3.7-21 Status and Numbers of Ponds and Impoundments, Proposed KMC

Pond or Impoundment Type	Anticipated Inventory, 2019	Anticipated Inventory, Life-of-Mine
Permanent	50	51
Temporary	115	142
Reclaimed	101	243

Source: PWCC 2016.

Also as described in Chapter 1.0, major structural practices that control runoff and its quality include temporary and permanent ponds, larger impoundments, stream diversions, and ditches and road drainage systems. On reclaimed lands, re-establishment of vegetative cover helps control overland flow, and benches along the slope contours control drainage on lands with OSMRE Permanent Program jurisdiction. Geomorphic reclamation is being conducted to promote more naturally functioning drainage. Structural practices in concentrated flow areas, such as rock-reinforced down-drains, check dams, and retention structures, reduce sediment yield and runoff from disturbed areas and minimize their off-site impacts. While they control accelerated runoff, erosion, and sediment yield, these structural practices also reduce surface water yields from the headwaters of the major drainages.

At the downstream edge of the leasehold, Moenkopi Wash at the PWCC monitoring locations has a watershed area of about 253 square miles. Similarly, Dinnebito Wash at the edge of the leasehold has a drainage area of about 51 square miles (OSMRE 2011a). This creates a combined drainage area of about 304 square miles at the downstream PWCC monitoring points for the leasehold.

As of June 2008, the Moenkopi Wash basin area impounded for water quality management within the leasehold was approximately 66 square miles. This is about 26 percent of basin area for Moenkopi Wash at the downstream edge of the leasehold (PWCC 2012 et seq.). The area planned to be impounded during 2013 was about 70 square miles (PWCC 2012 et seq.). Based on this recent disturbance estimate, it is projected that about 74.5 square miles of Moenkopi Wash basin area within the leasehold would be controlled by ponds and impoundments by the end of 2019. With this assumption, approximately 29.4 percent of the drainage area within the leasehold would be affected by retention of runoff and baseflow in ponds or impoundments at that time. Successful reclamation and pond removals would reduce that extent by increasing the area of free-draining landscapes. For EIS purposes, it is assumed that flow from 74.5 square miles (29.4 percent) of the Moenkopi Wash drainage area at the downstream edge of the leasehold would be subject to retention in the mine water management system at the start of either the 3-Unit Operation or 2-Unit Operation. Using a similar approach based on recent disturbance estimates, flow from a projected 6.9 square miles (13.5 percent) of the Dinnebito Wash basin area at the downstream edge of the leasehold would be subject to retention for water quality management at the end of 2019.

Based on 22 years of recordkeeping, PWCC has estimated that the average annual runoff is about 0.15 inch per year at the downstream leasehold monitoring stations on Moenkopi Wash (**Appendix WR-1, Figure WR-1.1**). Using that estimate, and assuming it applies to Dinnebito Wash as well, the average annual runoff from the overall 304 square miles leasehold drainage area without any retention would be approximately 2,432 acre-feet per year. Estimated magnitudes of runoff retained in 2019 for PWCC water quality management practices are projected in **Table 3.7-22**.

Note that these are general estimates made for purposes of comparison; actual retention would vary according to highly variable storms and annual conditions, as well as changes in actual pond numbers, volumes managed, and reclamation.

With implementation of the 3-Unit Operation, additional mining and accompanying water controls would occur in the N9, N10, N11 Extension, J19, and J21-W, coal resource areas (see Chapter 1.0). Activities in the J19 area and most of the J21 and N9 areas would occur within an existing controlled drainage. The remaining expansions would restrict additional runoff from approximately 10.5 square miles of additional watershed areas, mostly in the N11 Extension area. This value is approximate, and assumes that runoff from upgradient watershed areas would be routed into downslope retention structures. Under the 2-Unit Operation, the N10 coal resource area would not be mined. This area and a small upgradient watershed occupy roughly 2.1 square miles, assuming the drainages to the east would not be affected.

Table 3.7-22 Projected Runoff Effects of Structural Management Practices, 2019 Background

Local Drainage Basin (in and Above Leasehold)	Overall Area (square miles)	Projected Retained Area (square miles)	Projected Percent of Area Retained	Estimated Runoff Volume without Practices (acre-feet per year)	Projected Retained Runoff Volume (acre-feet per year)	Projected Percent of Local Runoff Retained
Moenkopi Wash	253	74.5	29.4	2,024	596.0	29.4
Dinnebito Wash	51	6.9	13.5	408	55.2	13.5
Total	304	81.4	26.8	2,432	651.2	26.8

Using a similar approach to runoff estimates as used for **Table 3.7-22** above, summaries of potential reductions in the calculated background mean annual runoff volume are presented in **Tables 3.7-23** and **3.7-24** for the 3-Unit Operation and 2-Unit Operation, respectively. As footnoted for the tables below, these estimates are for comparison purposes only, and are based on long-term averages and other assumptions. The actual unrestricted runoff volumes, and the retained or discharged volumes, would vary from year-to-year according to precipitation and evaporation conditions, pond construction or reclamation, and pond releases.

Table 3.7-23 Estimated Average Annual Leasehold Runoff Modifications at the End of Mining, 3-Unit Operation

Local Drainage Basin (in and above Leasehold) [1, 2]	Overall Area (square miles)	Projected Retained Area (square miles)	Projected Percent of Area Retained	Projected Retained Runoff Volume (acre-feet per year)	Projected Retention Increase from 2019 [3] (acre-feet per year)	Increase in Percent Local Retention from 2019
Moenkopi Wash	253	84.0	33.2	672.0	76.0	12.8
Dinnebito Wash	51	7.9	15.5	63.2	8.2	14.8
Total	304	101.1	33.3	735.2	84.2	12.9

[1] All values are estimates developed for purposes of comparison only, and assume no discharges from ponds or impoundments, or removal of ponds and impoundments after successful reclamation. Actual values would vary according to annual precipitation, extent of disturbance, and the status of ponds and impoundments.

[2] Estimates are for the areas of the Moenkopi Wash and Dinnebito Wash drainages near the downstream boundaries of the leasehold (PWCC monitoring Stations SW25 and SW34).

[3] Basis of comparison is Projected Retained Runoff Volume in 2019 background, **Table 3.7-22**.

Table 3.7-24 Estimated Average Annual Leasehold Runoff Modifications at the End of Mining, 2-Unit Operation

Local Drainage Basin (in and above Leasehold) [1, 2]	Overall Area (square miles)	Projected Retained Area (square miles)	Projected Percent of Area Retained	Projected Retained Runoff Volume (acre-feet per year)	Projected Retention Increase from 2019[3] (acre-feet per year)	Increase in Percent Local Retention from 2019
Moenkopi Wash	253	81.9	32.4	655.2	59.2	9.9
Dinnebito Wash	51	7.9	15.5	63.2	8.2	14.8
Total	304	89.8	29.5	718.4	67.4	10.3

[1] All values are estimates developed for purposes of comparison only, and assume no discharges from ponds or impoundments, or removal of ponds and impoundments after successful reclamation. Actual values would vary according to annual precipitation, extent of disturbance, and the status of ponds and impoundments.

[2] Estimates are for the areas of the Moenkopi Wash and Dinnebito Wash drainages near the downstream boundaries of the leasehold (PWCC monitoring Stations SW25 and SW34).

[3] Basis of comparison is Projected Retained Runoff Volume in 2019 background, **Table 3.7-22**.

From estimates depicted in **Table 3.7-23**, without releases or pond removals, the 3-Unit Operation could retain approximately 12.9 percent more runoff in the leasehold at the end of mining than was estimated for 2019. This would be a minor to moderate hydrologic impact during the active mining timeframe. After reclamation, there would be a net decline of about 6.6 percent from estimated 2019 conditions (26.8 in **Table 3.7-22** minus 20.2 in **Table 3.7-25**). As a comparative estimate, about 20 percent of runoff (**Table 3.7-25**) would be retained as water supply in ponds and impoundments after reclamation, a moderate hydrologic impact.

Table 3.7-25 Estimated Average Annual Leasehold Runoff Modifications after Post-mining Reclamation, 3-Unit Operation and 2-Unit Operation

Local Drainage Basin (in and above Leasehold) [1, 2]	Overall Area (square miles)	Projected Retained Area (square miles)	Projected Percent of Area Retained	Estimated Runoff Volume without Practices (acre-feet per year)	Projected Retained Runoff Volume (acre-feet per year)	Projected Percent of Local Basin Runoff Retained
Moenkopi Wash	253	57.5	22.7	2,024	460.0	22.7
Dinnebito Wash	51	3.8	7.5	408	30.4	7.5
Total	304	61.3	20.2	2,432	490.4	20.2

[1] All values are estimates developed for purposes of comparison only, and assume no discharges from ponds or impoundments, or removal of permanent post-mining ponds and impoundments. Actual values would vary according to annual precipitation, extent of disturbance, and operations of permanent ponds and impoundments.

[2] Estimates are for the areas of the Moenkopi Wash and Dinnebito Wash drainages near the downstream boundaries of the leasehold (PWCC monitoring Stations SW25 and SW34).

Source: Some information is derived from PWCC 2012 et seq.

From estimates depicted in **Table 3.7-24**, without releases or pond removals, the 2-Unit Operation could retain approximately 10.3 percent more runoff in the leasehold at the end of mining than was estimated for 2019. Similar to the 3-Unit Operation, after reclamation there would be a net decline of about 6.6 percent from estimated 2019 conditions (26.8 in **Table 3.7-22** minus 20.2 in **Table 3.7-25**). Similarly, as a comparative estimate about 20 percent of runoff would be retained under the 2-Unit Operation as water supply in ponds and impoundments after reclamation. Hydrologically, these would be moderate impacts.

The 3-Unit Operation would retain, as a comparative estimate, about 17 acre-feet per year more in the Moenkopi Wash drainage than the 2-Unit Operation. The effects of storage in the Dinnebito Wash drainage would be similar between the two Proposed Action options. At the end of mining and reclamation for either Proposed Action options, some contributing watershed areas would be restored as noted. Other runoff would be managed for local livestock watering and aquatic and wildlife habitat by permanent post-mining impoundments. This is part of existing agreements and approved post-mining land use objectives. Permanent post-mining impoundments could affect long-term runoff at the downstream edges of the leasehold as estimated in **Table 3.7-25**. Actual retention may vary.

Impacts to support of existing designated uses, as separately defined and established by the Navajo Nation and the Hopi Tribe in their respective surface water quality standards, would differ from the hydrologic impacts described above. Existing designated uses of surface water on and near the leasehold are restricted to wildlife and aquatic uses, occasional opportunistic livestock watering, and possibly limited opportunistic human contact such as wading or washing. These use categories are designated in the separate tribal water quality standards established by the Navajo Nation and the Hopi Tribe (**Appendix WR-1**). No irrigated agriculture or other uses exist on or near the leasehold. Although the additional retention of runoff at the proposed KMC would somewhat reduce average surface water flows in Moenkopi Wash and Dinnebito Wash in and near the leasehold, overall impacts to these uses would be negligible from either the 3-Unit Operation or 2-Unit Operation. Again, the table values are general estimates made for purposes of comparison; actual retention would vary according to highly variable storm conditions and pond releases. First of all, average conditions do not reflect that actual flow durations in the upper washes are ephemeral (or isolated intermittent); much of the time there is no water in the channels. In addition, discharges from ponds and impoundments do occur under suitable conditions, and may provide flows when streams may otherwise be dry. Due to evapotranspiration, the ephemeral nature of streamflows, and substantial seepage losses to the alluvium en route, background conditions allow little or no streamflow from the leasehold to contribute to distant downstream flows. Distant downstream Impacts from mine-related retention are none to negligible.

While there would be a hydrologic shift from channel flows to pond retention, the reason the overall impacts to water uses would be negligible is that a sizeable portion (e.g., half) of ponds and impoundments are open to livestock watering and wildlife. This provides additional grazing and habitat uses in the headwaters, and improves the availability of water compared to the ephemeral or limited intermittent channel reaches there. Permanent structures would provide these beneficial effects locally on Black Mesa during either Proposed Action options. Permanent impoundment uses also would remain as local beneficial effects after reclamation, in accordance with the existing mine plan and lease agreements.

Within or near the leasehold, riparian zones in the Moenkopi Wash watershed are most extensive along Coal Mine Wash, along Moenkopi Wash itself south and west of Navajo Route 41, and at the confluence of Moenkopi Wash and Red Peak Valley Wash. All of these areas are within the leasehold and do not appear to be adversely affected by past mine water management. They may be supported in part by releases from upstream ponds and impoundments, and by seepage from those facilities.

Another riparian zone starts about 1.5 miles below the confluence of Coal Mine Wash with Moenkopi Wash, and extends downstream for about another 3 miles. Its greatest width is within the upper 1.5 miles. Downstream of that, a narrower belt of riparian vegetation occurs along the channel. This zone is the only extensive, downstream riparian expression near the leasehold. It occurs in an eroded basin where the Mancos Shale is exposed at the land surface. The less permeable nature of the shale forces alluvial groundwater to remain near the surface. In combination with inflows and local shale runoff, this supports the riparian zone downstream until evapotranspiration and channel migration limit the further extent of riparian conditions.

Under a Proposed Action option, effects from reduced average runoff could occur at this nearby riparian area. Impacts could be too subtle to be detectable, however. The runoff reductions estimated above are fairly limited. Actual water reductions are likely to be limited as well, for the reasons noted above. Further, the extent of riparian habitat varies with multi-year precipitation conditions, and also as Moenkopi Wash migrates within its floodplain and terrace system. These factors would make impacts indistinguishable from ongoing natural processes. Because of these factors, retained storage impacts to riparian areas in or near the leasehold would be none to negligible.

- Scoping Concern: Reduced surface water quality from mining activities and discharges from the proposed KMC could adversely impact designated uses downstream along Moenkopi Wash or Dinnebito Wash.

Surface Water Quality Impacts from Activities or Discharges at the Proposed KMC, 3-Unit Operation	Surface Water Quality Impacts from Activities or Discharges at the Proposed KMC, 2-Unit Operation
Stream water quality would continue to be influenced mainly by background conditions. Trace element impacts would not occur or would be negligible. Sediment controls would restrict erosion and sedimentation impacts to negligible levels during mining, and reclaimed sediment yields would mimic undisturbed conditions. Minor localized impacts from TDS and sulfate concentrations would occur.	Potential impacts would be the same as described for the 3-Unit Operation.

Surface water quality could be adversely affected by either Proposed Action options. Runoff would carry sediment and other constituents from roads, active mine areas, reclamation in progress, coal processing areas, and storage yards. This would continue through the life-of-mine. Runoff would be collected in temporary or permanent sediment ponds and impoundments. As described in the Affected Environment section, numerous retention structures have been constructed in accordance with, or in excess of, regulatory requirements. The number and locations of these features would change as mining and reclamation proceed.

Currently, impounded water at the proposed KMC is retained indefinitely and pumped between ponds as needed, according to pool volumes and available storage capacities. Much of the retained volume evaporates, and a lesser amount seeps from some of the ponds. Discharges are pumped from selected ponds when sufficient volume and water quality have been attained through mixing and settlement. Receiving waters are Moenkopi Wash or Dinnebito Wash, either directly or through their tributaries. Existing USEPA NPDES permit provisions and associated monitoring form compliance goals for these activities. These approaches to runoff and sediment management would continue with either Proposed Action options.

As described previously, recent (2010 through 2014) data have been employed to describe current existing conditions at the mine. Although mining continues to modify watersheds, no recent surface water data are available upstream of the mine. In the available surface water data for 2010 through 2014, occasional exceedances of tribal standards occur for total recoverable trace elements including aluminum, arsenic, cadmium, copper, lead, mercury, and vanadium. Most of the time, however, trace element concentrations in recent surface water samples are below laboratory detection limits (**Appendix WR-1**). When they are above detectable levels, these several constituents are somewhat consistent in exceeding standards for listed designated uses. Most involve total recoverable concentrations (no TSS filtered from the sample), whereas their dissolved concentrations (TSS filtered from the sample prior to analysis) rarely exceed standards. The most restrictive standards and/or common standards exceedances for these constituents are summarized below. It should be noted that standards and their corresponding criteria vary between the Navajo Nation and the Hopi Tribe (**Appendix WR-1**).

- Total aluminum, chronic, for aquatic and wildlife habitat;
- Total arsenic, for fish consumption or full body contact;
- Total cadmium, for fish consumption;
- Total copper, for livestock watering;
- Total lead, for full body or secondary human contact and livestock watering;
- Total mercury, chronic, for aquatic and wildlife habitat;
- Total selenium, chronic, for aquatic and wildlife habitat;
- TSS for aquatic and wildlife habitat; and
- Where Hopi tribal water quality standards apply, total iron, TDS, sulfate, and total vanadium concentrations also commonly exceed criteria.

Fish consumption or full body contact are probably not common or regular uses of upper Moenkopi Wash, upper Dinnebito Wash, or any of their tributaries within or near the leasehold. Further discussions of ecological and human health risks related to water quality are presented in Sections 3.0.3 (Ecological and Human Health Risk Assessment Approach), 3.10.2 (Terrestrial Wildlife Resources), and 3.12.2 (Aquatic Biological Resources). Additional risk assessment details are presented in **Appendix 3RA**. Studies conducted for the ERA at the mine indicate that total arsenic and cadmium do not pose unacceptable risks in streams (Ramboll Environ 2016d). Therefore, related arsenic and cadmium exceedances are not considered further. The chronic aluminum and mercury criteria (respectively, 0.087 mg/L and 0.001 µg/L) for aquatic and wildlife habitat are so low that, given background sources, they are likely to be exceeded in local or regional streamflows whether PWCC mining activity is present or not.

Further, aluminum was not detected in 25 percent of recent samples on lower Moenkopi Wash (Site SW26). Mercury was not detected in 38 percent of samples there.

An examination of long-term data (**Appendix WR-1, Tables WR-1.17** through **WR-1.20**) indicates that both total and dissolved iron concentrations typically declined on Moenkopi Wash from upstream of the mine to the downstream limit of the leasehold. On Dinnebito Wash, long-term (1985 through 2005) average total iron concentrations increased somewhat from upstream to downstream, but the median values declined from upstream to downstream. Importantly, dissolved iron concentrations were low on both washes over the long term in a slightly alkaline setting. Because of these data results and considerations, impacts from these five constituents (aluminum, arsenic, cadmium, iron, and mercury) due to mining activities under a Proposed Action option would not occur.

Of the remaining constituents listed above, copper and lead could adversely affect livestock watering under either Proposed Action options. Selenium and TSS could adversely affect habitat uses under either Proposed Action options. However, copper was not detected in 50 percent of recent samples on downstream Moenkopi Wash (Site SW26); lead was not detected in 50 percent of recent samples there, and selenium was not detected in 56 percent of samples there (**Appendix WR-1, Table WR-1.11**). Recent data for Dinnebito Wash (**Appendix WR-1, Tables WR-1.15** and **WR-1.16**) indicate elevated concentrations of total copper, total lead, and total selenium in comparison to standards. These data reflect only storm runoff conditions, with TSS concentrations much greater than those in Moenkopi Wash samples representing both runoff and baseflow. The storm sediment load affects those results on Dinnebito Wash, where much of the watershed is undisturbed and contributes to water quality conditions.

Recent (2010 through 2014) total vanadium and total chromium concentrations also are typically elevated in runoff from Moenkopi Wash and Dinnebito Wash, in samples where they are detected. However, these constituents are not detected in many monitoring samples (**Appendix WR-1** tables), particularly in dissolved forms represented by longer-term data. For example, neither dissolved chromium nor dissolved vanadium were ever detected in long-term (1985 through 2005) downstream samples at Station CG34 on Dinnebito Wash (**Appendix WR-1, Table WR-1.20**). Criteria are not listed for total vanadium on Navajo Nation lands, and average or median total chromium concentrations approximate the livestock criteria at lower Coal Mine Wash, Red Peak Valley Wash, and lower Dinnebito Wash (**Appendix WR-1, Tables WR-1.8**, **WR-1.13**, and **WR-1.16**, respectively).

The recent results indicate that if total concentrations of chromium, copper, lead, selenium, and vanadium are: 1) sufficiently present to be detectable; and 2) biologically available, they could reduce surface water quality for habitat uses or livestock watering within and near the coal lease areas over time. It should be noted that these total constituents are not detected in all recent samples, however, particularly in the Moenkopi Wash drainages. In addition, both recent and long-term dissolved concentrations of these constituents are typically well below standards for habitat and livestock watering, and the dissolved fraction is usually the most biologically available. Therefore, over the planned life of the Proposed Action and later, overall mining effects on designated uses from trace elements in surface flows would probably be undetectable.

TSS concentrations typically exceed applicable water quality standard both upstream and downstream of mining activities. TSS values in lower Coal Mine Wash (Site SW25) are lower than stations over on the Moenkopi Wash mainstem. In combined Moenkopi Wash drainages, long-term data indicate that average TSS concentrations declined by about 21 percent from upstream to downstream (**Appendix WR-1, Tables WR-1.17** and **WR-1.18**, respectively). The median concentrations were similar from upstream to downstream. These outcomes likely result from the extensive erosion and sedimentation controls within the Moenkopi Wash drainages. Along Dinnebito Wash, available long-term data indicate that typical TSS concentrations increased by about 40 to 50 percent from upstream to downstream (**Appendix WR-1, Tables WR-1.19** and **WR-1.20**, respectively). Large parts of the Dinnebito Wash drainage remain undisturbed and un-managed by structural practices. In arid areas, it is not unusual for TSS concentrations to increase in downstream flows, due to naturally erosive landscapes and re-mobilized channel storage or bank erosion. These are significant contributors to sediment supply and transport throughout the project region. In addition, TSS concentrations can vary widely with localized, short-term storm conditions. The existing conditions and management applications would continue in the Moenkopi Wash drainages and along Dinnebito Wash under either Proposed Action options.

Based on recent and historical data, TSS concentrations from disturbed areas are well controlled by mine water management, In addition, OSMRE conducts quarterly inspections of reclamation, water conveyance structures and sediment ponds at the Kayenta Mine, and semi-annual inspections of all areas at the inactive former Black Mesa Mine area. PWCC also conducts ongoing inspections to meet permit conditions. Both protocols include remedial actions and monitoring if problems are encountered. Because of all these factors, no detectable TSS impacts would occur during a Proposed Action option.

Runoff, erosion, and sediment transport within the coal leaseholds were intensively monitored by PWCC at stream monitoring stations established along the larger channels and within small watersheds during a long-term field study (PWCC 2012 et seq.). These involved comparisons of disturbed and undisturbed conditions, stream channel monitoring, and runoff and erosion plots. Based on all of the various study results and corresponding modeling efforts, retention structures and other drainage control features have been designed and constructed by PWCC in accordance with water quality OSMRE guidelines, design requirements, NPDES permit stipulations, and reclamation objectives. The SEDIMOT II/SEDCAD model and/or EASI model were used as design tools (PWCC 2012 et seq.) or to evaluate spoil grading plans and overall watershed characteristics during reclamation planning. Modeling inputs and reviews were tailored to the field study results, and outputs compared well to actual conditions for undisturbed, active, and reclaimed areas.

In addition to managing runoff, erosion, and sediment during proposed active mining, these efforts are useful for projecting long-term future conditions during and after proposed reclamation. To compare pre-mining and post-mining conditions, both the SEDIMOT II/SEDCAD and EASI models were employed by PWCC. Initial historical work used the former approach, and more rigorous work subsequently used the EASI model (PWCC 2012 et seq.). Both efforts indicated that average annual sediment yield after successful reclamation would be equal to or less than pre-mining conditions. This is anticipated to be a local effect of reclamation and stabilization practices. Notably, on broader watershed scales both within and beyond the coal leasehold, natural background sediment contributions will continue to affect Moenkopi and Dinnebito washes with or without a Proposed Action option. While some material will originate from hillslopes, more substantial sediment dynamics (erosion, sediment storage and transport) will naturally result from existing lateral inflows and channel bed-and-bank conditions downstream of mining activities along the major washes, These processes will be similar to current background conditions in the region, such as along lower Moenkopi and Dinnebito washes, Polacca Wash, or Jeddito Wash. In addition, sediment yields and other water quality characteristics vary substantially with localized runoff conditions.

After proposed mining, reclamation would involve recontouring and terracing with geomorphic considerations to restore stable hillslopes and drainages. Revegetation, removal of temporary sediment ponds, and implementation of alternative sediment control measures would support long-term stabilization and post-mining land uses (PWCC 2012 et seq.). PWCC conducted rigorous EASI runoff and sediment yield modeling, with results that compared well to monitoring program results. Based on post-mining projections stemming from that effort, sediment ponds could be removed and reclaimed, and best management practices would successfully control sediment yields to less than or equal to the average annual sediment yield from pre-mining watersheds. In addition to the post-mining projections, post-reclamation monitoring is required by OSMRE to demonstrate the success of reclamation practices. With this long-term control of sediment yield from mining disturbance, TSS concentrations after reclamation would likely be similar to or less than those from disturbed conditions.

Because of these factors, no long-term post-mining impacts from erosion or sediment yield would occur from a Proposed Action option.

Recent (2010 through 2014) PWCC surface water data generally indicate elevated concentrations of TDS and sulfate across the leasehold. Some of this is due to natural background conditions, as documented upstream of the mine from both stream and native spring monitoring and long-term data. Baseflow concentrations sometimes exceed recommended livestock watering values for sulfate (1,000 mg/L); and TDS (3,000 mg/L) (Raisbeck et al. 2008; Sigler and Kleehammer 2013). Concentrations are typically much less during runoff. Hopi tribal water quality standards for aquatic and wildlife habitats are consistently exceeded at downstream monitoring sites, but again, natural background conditions contribute to this based on long-term data.

Recent (2010 through 2014) data for Dinnebito Wash indicate that TDS and sulfate values are relatively low at the leasehold boundary (median values of 370 mg/L and 158 mg/L, respectively, at Site SW34). They increase further downstream at location CG34. In contrast, long-term (1985 through 2005) data show that background values of both TDS and sulfate are greater on Dinnebito Wash upstream of the mine than downstream (**Appendix WR-1, Tables WR-1.19** and **WR-1.20**). The contrast is due to flow conditions at the time of sampling, and the number of samples. Recent data (**Appendix WR-1, Tables WR-1.15** and **WR-1.16**) are comprised of storm runoff only, from eight samples upstream at SW34 and six samples downstream at CG34. At both stations, recent data reflect several samples taken during a single day or runoff event. There is substantial recent water quality variation due to the timing of sampling with respect to phases of the storm runoff hydrograph. In the long-term data set, these factors have less influence. The long-term data indicate that upstream inflows have greater TDS and sulfate concentrations as a natural background condition, and that typical values decline downstream (**Appendix WR-1, Tables WR-1.19** and **WR-1.20**).

Recent (2010 through 2014) TDS and sulfate concentrations on Moenkopi Wash are typically elevated, largely due to baseflow concentrations. Average and median long-term data (1981 through 2008) are substantially less, and typically both upstream and downstream long-term conditions are well within water quality guideline values. Typical long-term (1981 through 2008) background values of both TDS and sulfate are greater downstream of the mine on Moenkopi Wash (**Appendix WR-1, Tables WR-1.17** and **WR-1.18**).

Overall, it is likely that some of the sulfate and TDS concentrations occur naturally, and some increases may result from mining effects. This is based on older historical data and native spring samples indicating that high concentrations exist upgradient of the mine (for example, see **Appendix WR-3, Table WR-3.1**), These conditions are likely to continue through the planned life-of-project and beyond, under either Proposed Action options. As a result, occasional concentrations of TDS and sulfate are likely to be greater than habitat standards or unofficial livestock watering guidelines. Because of the background contributions, and the likelihood of local adaptations to water quality by local livestock or wildlife, these would be minor localized impacts. Both upstream and downstream of the leasehold, water quality would continue to be influenced by highly localized precipitation conditions and geologic sources of these constituents. Impacts to distant downstream surface water quality would be none to negligible.

3.7.4.2.2.7 Ponds and Impoundments

- Scoping Concern: Ponds and Impoundments at the proposed KMC might not be adequately built or maintained to control runoff and provide supplemental water supplies. Water quality in ponds and impoundments may not be suitable for existing designated uses.

Impacts from Pond and Impoundment Characteristics at the Proposed KMC, 3-Unit Operation	Impacts from Pond and Impoundment Characteristics at the Proposed KMC, 2-Unit Operation
Retention structures would be designed, constructed, and maintained to meet or exceed applicable agency requirements. No impacts would occur related to this consideration. Moderate temporary exceedances of habitat selenium standards or recommended sulfate and/or TDS guidelines may occur in some temporary ponds in the northern area of the leasehold. Long-term water quality in permanent ponds and impoundments would support existing designated uses without impacts.	Potential impacts would be similar to those described for the 3-Unit Operation, but there would be minor or no impacts from selenium, sulfate, or TDS in northern area temporary ponds.

Over the life of either Proposed Action options, the locations of ponds and impoundments would change as mining and reclamation proceed. Sediment ponds would be created to serve new mining activities, and others would be removed after successful reclamation. The timing of these changes is somewhat unknown, since pond locations and designs would depend on selection of a project alternative. In any case, these structures would be designed, constructed, inspected and maintained in accordance with, or in excess of, applicable OSMRE and Mine Safety and Health Administration regulatory requirements. This would be consistent with existing PWCC practices within the coal leasehold. The potential effects of ponds and impoundments on surface flows and runoff are discussed above.

Pond water quality data reflect areas and activities similar to what would be involved in either Proposed Action options. Suspended solids concentrations were low in all retained water. Trace element concentrations were generally low, and often were below detection limits (**Appendix WR-2, Tables WR-2.2** and **WR-2.3**). Typical total selenium concentrations, when detected, exceeded aquatic and wildlife habitat criteria. However, total selenium was only detected in 15 percent of samples (one out of seven) from the J16-J21-J28 part of the leasehold, and in 50 percent of samples (6 out of 12) from the N2 through N11 part. Sulfate and TDS concentrations were generally low in retained water in the southeastern part of the leasehold (J coal resource areas). These constituent concentrations were considerably higher in samples from existing ponds in the northwestern part of the leasehold along Coal Mine Wash ("N" coal resource areas as depicted in **Appendix WR-2, Figure WR-2.1**, and chemical data reported in **Appendix WR-2, Table WR-2.3**). Livestock watering and aquatic and wildlife habitat uses would be temporarily impacted by TDS and sulfate concentrations in some ponds associated with the N coal resource areas.

In the northern part of the leasehold, effects to water uses would likely occur from additional sources of selenium, sulfate and TDS at some temporary sediment ponds. Further review of pond water quality data from the N10-N11 area along Coal Mine Wash indicates a median TDS value of 2,825 mg/L, and a median sulfate concentration of 1,720 mg/L. Based on this information, there may be moderate temporary impacts during mining activities to livestock watering and aquatic and wildlife designated uses in the N10-N11 coal resource areas. Since these temporary ponds are used only for sediment and storm water retention, other uses would be incidental. Other ponds nearby would provide water for livestock watering and habitat uses. Impacts would be less (negligible or minor) under the 2-Unit Operation, since the N10 area would not be mined in that option. No impacts to pond or impoundment water quality are anticipated in the southern part of the leasehold, under either temporary or permanent conditions. Generally, retained water there is well-suited for livestock watering and aquatic and wildlife uses.

Both north- and south-area permanent ponds generally have much lower median concentrations, with an overall TDS value of 1,260 mg/L and a sulfate value of 710 mg/L in the north based on recent sampling. So over the long term, post-mining pond water quality on the reclaimed areas would be adequate for aquatic and wildlife uses and livestock watering.

In compliance with Surface Mining Control and Reclamation Act regulations and the OSMRE-approved permit, most ponds would be removed and their locations reclaimed as mining progresses, Permanent ponds and impoundments would remain as agreed upon with tribal authorities and OSMRE permit approvals. The persistence of water in permanent ponds is satisfactorily addressed in the Permit Application Package. Its long-term suitability for common uses is demonstrated in monitoring data and annual reports submitted to OSMRE. It is assumed for purposes of this EIS that tribal authorities would conduct due diligence assessments of conditions at permanent ponds and impoundments prior to transfer of ownership from PWCC. It also is assumed that any sediment quality issues or other considerations related to pond or impoundment conditions would be resolved as needed between tribal authorities and PWCC prior to ownership transfers.

3.7.4.2.3 Transmission Systems and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

Numerous ephemeral and intermittent streams are crossed by the transmission line alignments. The following streams have perennial flow segments within the transmission line ROWs:

- WTS – Colorado River, Paria River, Muddy River, Virgin River, Las Vegas Wash, and Meadow Valley Wash.
- STS – Agua Fria River, Big Bug Creek, and Verde River.

Operations and maintenance activities along transmission lines and at communication sites are described in **Appendix 1B**. In particular, Tables 7 and 8 in **Appendix 1B** identify activities anticipated during the Proposed Action or alternatives. Table 9 in **Appendix 1B** identifies activities that are not part of the Proposed Action or alternatives; those would require separate authorizations from appropriate land management or water resources agencies.

- Scoping Concern: Water quality in streams crossed by transmission lines could be reduced by construction or maintenance activities in the ROWs.

Water Quality Impacts from Transmission Line Construction or Maintenance Activities, 3-Unit Operation	Water Quality Impacts from Transmission Line Construction or Maintenance Activities, 2-Unit Operation
No impacts to water quality would occur from operation and maintenance activities conducted in accordance with permit conditions along either transmission system during the Proposed Action.	Potential impacts would be the same as those described for the 3-Unit Operation.

Activities that could result in adverse effects to water resources from a Proposed Action option include:

- Applications of herbicides, pesticides or rodenticides;
- Vehicle and equipment staging along transmission line ROWs; and
- Erosion control projects along transmission line ROWs.

These activities could primarily affect surface water or shallow groundwater resources. Adverse effects to water quality could result if spills or leaks of fuels, lubricants, or other chemicals occurred in or near stream channels, or if disturbance led to accelerated erosion and sedimentation. In addition, if toxic levels of chemical treatments were directly applied to waterbodies or transported in runoff, adverse surface water quality and related habitat impacts could result.

To avoid such impacts, herbicides and pesticides would be managed within appropriate material storage and handling guidelines, and would be selected and applied according to land management agency procedures and approvals. Impacts from other activities near channels, or through channel crossings, would be avoided by compliance with approved nationwide permits (e.g., U.S. Army Corps of Engineers Nationwide Permit 12), federal or tribal agency ROW permit reviews and approvals, and corresponding permit provisions or stipulations. These would address the staging of vehicles, equipment, and fluids with respect to streams, washes, and floodplains; spill prevention, response, and reporting; crossing conditions and erosion controls; and other best management practices.

Because of implementing these practices and procedures, and complying with other agency requirements, none to negligible impacts to water resources would occur from operation and maintenance activities along either transmission system during the Proposed Action operating period.

3.7.4.2.4 Project Impact Summary – All Project Components

As mentioned in Section 3.7.4.1 (Assumptions, Impact Methodology, and Issues), recent background conditions (2010 through 2014) formed the primary basis for the preceding impact assessments. Some longer-term data also were used to examine potential future impacts from a Proposed Action option. Cumulative effects (from past, present, and reasonably foreseeable activities) are examined in following parts of this water resources section.

At the NGS, the direct and indirect impact assessment for the Proposed Action focuses on the potential for:

- Impacts to surface water and the N-Aquifer from plant operations and facilities;
- Water supply withdrawal effects on Lake Powell; and
- Airborne deposition impacts from selected trace elements on surface water quality in Lake Powell and the Colorado River downstream.

No impacts to water resources would occur at the facility due to proposed operations and maintenance. Environmental programs and compliance with regulatory requirements at NGS (e.g., CCR regulations), and implementation of the Groundwater Protection Plan and Perched Water Dewatering Plan would protect the N-Aquifer and surface water. Ultimately, plant closure, materials disposition, and plant site reclamation would be conducted as described in the decommissioning description (**Appendix 1B**) implemented pursuant to applicable laws and regulations. Withdrawals from Lake Powell would create negligible impacts on reservoir water levels and the extent of the lake water surface. Negligible amounts of arsenic, mercury, or selenium would be deposited on Lake Powell or the nearby Colorado River from plant emissions. Overall impacts to water resources from either Proposed Action options at the NGS would be none to negligible.

At the Proposed KMC, the direct and indirect impact assessment for a Proposed Action option focuses on the potential for:

- Mine-related pumping impacts to N-Aquifer groundwater levels and water quality;
- Reduced discharges in N-Aquifer springs and supported stream baseflows;
- Reduced groundwater levels and water quality in the shallower Wepo and alluvial aquifer zones;
- Reduced flow rates, occurrence, or water quality at shallow springs and seeps, and corresponding effects on existing water uses in and near the coal leasehold;

- Reduced flows or water quality in stream channels and corresponding effects on existing water uses in and near the coal leasehold; and
- Additional retention of surface runoff in ponds and impoundments, and the suitability of retained water quality to support water uses in the mine-area locale.

Mine related pumping would create predicted maximum N-Aquifer drawdowns of about 35 feet at Forest Lake in the year 2046, about 18 feet at Chilchinbito in 2040, about 16 feet at Pinon in 2051, and about 14 feet at Kayenta in 2097. At other communities, predicted maximum drawdowns range from essentially zero up to about 12 feet. Negligible drawdowns would occur at Tuba City and Moenkopi. The maximum increases in pumping lift due to the Proposed Action (3.1 to 3.7 percent) would occur at Kayenta, Forest Lake, and Chilchinbito. The predicted range in percent increased pumping lift for all communities varies from zero to a maximum of 3.7 percent; the median value is 0.7 percent. Based on the predicted results, these effects would comprise negligible to minor impacts.

There would be no changes to N-Aquifer water quality. Effects on stream baseflows would be none to negligible, depending on the stream. Similarly, the potential impacts to discharges at N-Aquifer springs from either Proposed Action options would be none to negligible.

During either Proposed Action options, groundwater levels in the Wepo Formation and alluvial aquifers within and adjacent to the leasehold would continue to vary with background climatic conditions (including drought or wet cycles), local differences in recharge, and mine pit configurations. Project impacts would be none to negligible. Water quality effects in the Wepo Formation, alluvial aquifers, and associated springs and seeps would range from none to minor, and would be localized to a few isolated locations within the leasehold. Any impacts to existing water uses would be mitigated by PWCC ponds and impoundments and ongoing seep mitigation.

The amount of watershed area directed to ponds and impoundments would change over time as mining and reclamation move across proposed mine areas. There would be moderate hydrologic impacts from shifts to retention storage along Moenkopi Wash or Dinnebito Wash within and adjacent to the leasehold. These would decline after reclamation at the end of proposed mining, and would not affect flows available for distant uses along Moenkopi or Dinnebito washes. In addition, permanent ponds would mitigate impacts to uses and improve local water availability on and near the leasehold. Stream water quality would continue to be influenced mainly by background conditions. Trace element impacts would not occur or would be negligible. Sediment controls would restrict erosion and sedimentation impacts to negligible levels during mining, and reclaimed sediment yields would mimic undisturbed conditions. Minor localized impacts from TDS and sulfate concentrations could occur to stream water quality, but would be mitigated by suitable water quality in ponds and impoundments.

Operation and maintenance of transmission systems, and coordination with applicable land management agencies for these activities, is described in **Appendix 1B**. NGS would decommission the transmission systems in accordance with the requirements of respective agencies and the sequence described in **Appendix 1B**. By implementing the operations and maintenance plans and complying with permit requirements and other agency stipulations, none to negligible impacts to water resources would occur along transmission line ROWs.

3.7.4.2.5 Cumulative Impacts

Cumulative impacts are based on considerations of past, present, and reasonably foreseeable actions and their potential effects on water resources in combination with the Proposed Action. Specifically, these other actions include:

- Trace element emissions from other regional coal-fired generation sources;
- The Glen Canyon Dam Long-term Experimental and Management Plan;

- The Navajo-Gallup Pipeline Project in New Mexico;
- The proposed Lake Powell Pipeline Project in Utah;
- Past, present and future N-Aquifer pumping by communities;
- Historic N-Aquifer pumping by PWCC; and
- Other downstream tribal surface water diversions and retention structures for livestock watering and agricultural production.

The first four listed activities were detailed in Section 3.0, under “Cumulative Impacts.” The last two activities involve potential effects from the proposed KMC and other users; these are further detailed in the text below. The potential mine-related cumulative effects also are summarized below in **Tables 3.7-26** and **3.7-27**. This cumulative assessment emphasis is on the Proposed Action 3-Unit Operation; cumulative impacts from the 2-Unit Operation would be slightly less for concerns related to airborne deposition and withdrawals from Lake Powell.

From public and agency scoping, cumulative impact concerns include:

- Combined airborne deposition of As, Hg, and Se from NGS and other sources could affect the quality of surface water and sediments in Lake Powell, and in parts of the Colorado River and San Juan River watersheds;
- Combined water supply withdrawals from Lake Powell would further reduce water levels and the reservoir extent;
- Past, present, and future N-Aquifer pumping at communities would interact with mine-related pumping effects to further decrease N-Aquifer water levels and contributions to connected springs or baseflows in streams;
- Past mine-related pumping effects have created drawdown in N-Aquifer wells and historically reduced groundwater contributions to springs and baseflows in streams;
- Land fissures and landslides in the Blue Gap area and elsewhere could be caused by historic or proposed groundwater pumping at the coal leasehold or from anticipated increased community pumping over time; and
- Potential effects of climate change on water resources availability within the study areas (Section 3.2).

3.7.4.2.5.1 Trace Element Emissions from Regional Coal-fired Generation Sources

- Scoping Concern: Airborne emissions from regional coal-fired power plants could contribute additional levels of arsenic, mercury, selenium, and acid-forming compounds to major waterbodies in the study area, including the Colorado River, San Juan River, and Lake Powell.

Water Quality Impacts in Major Waterbodies from Airborne Emissions, 3-Unit Operation	Water Quality Impacts in Major Waterbodies from Airborne Emissions, 2-Unit Operation
Cumulative impacts to surface water resources within the near-field study area and the Colorado River gap regions from cumulative source deposition of arsenic, mercury, and selenium would be none to negligible. Along the San Juan River, cumulative mercury deposition impacts would be none to negligible, arsenic impacts would be minor, and selenium impacts would generally be moderate but could be greater. Acid deposition impacts from NGS would not occur in the water resources study area, and so would not contribute to cumulative impacts.	Potential impacts would be somewhat less than those described for the 3-Unit Operation.

Other sources of trace element deposition include the Four Corners Power Plant and the San Juan Generating Station (EPRI 2016; Ramboll Environ 2016a). Predicted combined airborne deposition rates were modeled for the cumulative source cases using an approach similar to that used for the direct impact analysis. For the near-field area (20-km radius from NGS), the predicted arsenic and selenium contributions from these Other Cumulative Sources to surface water concentrations in mg/L are zero out to ten decimal places (see the bar charts in the ERA appendices). For total and dissolved mercury, contributions in mg/L are zero out to six and eight decimal places, respectively. Because of these values, impacts to surface water resources within the near-field study area from cumulative source deposition of these trace elements would be none to negligible.

Predicted trace element airborne deposition rates in the southwest gap region (Colorado River downstream of Lake Powell) and the northeast gap region (see the Ecological Risk Assessment) are generally similar to those described for the near-field conditions. They may vary by an order of magnitude, but are still negligible in relation to baseline conditions. Because of this, impacts to surface water resources within the gap regions from cumulative source deposition of these trace elements would be none to negligible.

Along the San Juan River, predicted combined contributions of total and dissolved mercury would be similar to those described for the near-field (20-km) conditions. Related mercury impacts would be none to negligible. For arsenic, total and dissolved combined contributions are predicted to be greater along the San Juan River, on the order of 0.00012 mg/L (0.12 µg/L) as a worst case. Baseline dissolved arsenic concentrations in the river range from approximately 1.2 µg/L (**Table 3.7-7**) to 2.2 µg/L (Ramboll Environ 2016a). Because of this, minor impacts to surface water quality would occur from combined arsenic depositions along the San Juan River. For selenium, baseline dissolved concentrations in the San Juan River are approximately 1.1 µg/L (**Table 3.7-7,** and Ramboll Environ 2016a). Combined selenium contributions are predicted to be 0.33 µg/L (a 30 percent increase) as a worst-case. Because of this, under more typical effects, moderate impacts to surface water quality would occur from combined selenium depositions along the San Juan River.

These effects would subject to further environmental processes within the aquatic ecosystem. The ecological effects of predicted water quality impacts from arsenic and selenium in combined-source depositions along the San Juan River are further examined in the ERA and Aquatic Biology assessments.

3.7.4.2.5.2 Cumulative Effects on Lake Powell Extent and Water Levels from Combined Project Withdrawals

- Scoping Concern: Other federal or state actions or reasonably foreseeable projects would increase surface water withdrawals from Lake Powell, reducing its surface extent and the depth of water needed for uses along the shorelines (e.g., recreation, biological habitats).

Reduction of Lake Powell Extent or Depth from Additional Withdrawals by Other Projects, 3-Unit Operation	Reduction of Lake Powell Extent or Depth from Additional Withdrawals by Other Projects, 2-Unit Operation
Under normal pool conditions, potential reservoir surface acreage reduction would be about 540 acres, with a reduction in depth of about 9 inches. These would be negligible impacts. Under severe drought conditions, potential reservoir surface acreage reduction would be about 683 acres, with a reduction in depth of about 19 inches. These would be negligible or greater impacts, depending on location, recreational or commercial uses, or shoreline habitats.	Potential impacts would be negligible, and somewhat less than those described for the 3-Unit Operation.

Several existing or reasonably foreseeable actions are of interest with respect to the potential reservoir impact concerns described above. These actions are summarized below, and then assessed for cumulative impacts.

<u>Glen Canyon Dam Long-term Experimental and Management Plan</u>

This planning effort was previously described in Section 3.0. Management of Lake Powell releases is not part of the NGS Proposed Action or any alternative. If any downstream effects occurred from managing Lake Powell releases, they would not be due to any NGS project operations. Most Long-term Experimental and Management Plan alternatives would not change releases (Reclamation 2015b). Monthly release volumes under Alternative C in August through November would be lower than those under most other alternatives to reduce sediment transport rates during the monsoon period. Release volumes in the high power demand months of December, January, and July would be increased to compensate for water not released in August through November, and volumes in February through June would be patterned to follow the monthly hydropower as defined by the contract rate of delivery (Reclamation 2015b).

Under Alternative F of the plan, peak flows would be lower than pre-dam magnitudes to reduce sediment transport and erosion given the reduced sand supply downstream of the dam. Peak flows would be provided in May and June, which corresponds well with the timing of the pre-dam peak. The variability in flows within the peak also would serve to water higher elevation vegetation. There would be no within-day fluctuations in flow (Reclamation 2015b).

If Long-term Experimental and Management Plan Alternatives C or F were to be implemented, seasonal changes from current water temperature and dissolved oxygen regimes would result in the Colorado River downstream of Lake Powell (the "Southwest Gap Region"). The magnitudes and extents of such changes are unknown, but there would not be an incremental effect caused by any NGS alternative.

<u>Navajo-Gallup Pipeline Project</u>

The Navajo-Gallup Pipeline would use water exchanged in storage within Navajo Lake outside of the study area. No additional water would be removed from the San Juan River downstream of Navajo Dam that would not first originate from upstream reservoir releases (Reclamation 2009). An anticipated average annual return flow of approximately 1,870 acre-feet would occur at the western end of the project. Cumulative effects to Lake Powell water levels or water quality would not occur.

Proposed Municipal Lake Powell Pipeline Project

As described at the beginning of Chapter 3.0, the proposed Lake Powell Pipeline project would withdraw approximately 86,249 acre-feet of water per year at full capacity. The effects of these withdrawals are compared to NGS withdrawals (3-Unit Operation and 2-Unit Operation) under normal and drought conditions in **Tables 3.7-26** and **3.7-27**.

As can be seen from **Table 3.7-26**, the total effect of combined withdrawals with the Proposed Action 3-Unit Operation would lower Lake Powell by about 9 inches under normal pool conditions, and by about 19 inches under extreme drought conditions. The reductions in lake extent would be about 540 acres and 685 acres under the normal and drought conditions, respectively. Seasonal conditions and wind effects would modify these estimates. Still smaller reductions are estimated for the Proposed Action 2-Unit Operation in the second table. Because the lake occupies about 160,800 acres at normal pool and about 73,800 acres at its historic drought elevation, these effects would be negligible impacts.

Table 3.7-26 Cumulative Effects with Proposed Action 3-Unit Operation Withdrawals on Lake Powell Extent and Depth

Assumed Lake Powell Pool Condition, (Water Elevation, feet amsl) [1]	Diversion Source	Anticipated Withdrawal, (acre-feet/yr)	Withdrawal Effects, Reduction in Reservoir Extent (acres)	Withdrawal Effects, Reduction in Reservoir Depth (inches)
Full (3,700)	Proposed Action, 3-Unit Operation	29,000	132.1	2.1
Full (3,700)	Reasonably Foreseeable (Lake Powell Pipeline)	86,250	407.0	6.4
Full (3,700)	Total	114,250	539.2	8.6
Drought (3,555)	Proposed Action, 3-Unit Operation	29,000	167.1	4.6
Drought (3,555)	Reasonably Foreseeable (Lake Powell Pipeline)	86,250	515.6	14.1
Drought (3,555)	Total	114,250	683.0	18.7

[1] Tabulated values reflect arithmetic rounding differences and interpolation from existing Lake Powell data.

Source: Reclamation 2009, 2007; Washington County Water Conservancy District 2016

Table 3.7-27 Cumulative Effects with Proposed Action 2-Unit Operation Withdrawals on Lake Powell Extent and Depth

Assumed Lake Powell Pool Condition, (Water Elevation, feet amsl)[1]	Diversion Source	Anticipated Withdrawal, (acre-feet/yr)	Withdrawal Effects, Reduction in Reservoir Extent (acres)	Withdrawal Effects, Reduction in Reservoir Depth (inches)
Full (3,700)	Proposed Action, 2-Unit Operation	18,700	88.3	1.4
Full (3,700)	Reasonably Foreseeable (Lake Powell Pipeline)	86,250	407.0	6.4
Full (3,700)	Total	104,950	495.3	7.8
Drought (3,555)	Proposed Action, 2-Unit Operation	18,700	111.6	3.0
Drought (3,555)	Reasonably Foreseeable (Lake Powell Pipeline)	86,250	515.6	14.1
Drought (3,555)	Total	104,950	627.4	17.2

[1] Tabulated values reflect arithmetic rounding differences and interpolation from existing Lake Powell data.

Source: Reclamation 2009, 2007; Washington County Water Conservancy District 2016.

3.7.4.2.5.3 Cumulative Effects on N-Aquifer Water Levels, Water Quality, and Uses

- Scoping Concern: Past groundwater drawdown from mine-related pumping combined with past community water supply withdrawals has created greater depths to water in N-Aquifer wells and reduced flows at associated streams and springs.

Past Impacts of Mine-Related and Community Pumping on N-Aquifer Wells, Stream Baseflows, and Springs, 3-Unit Operation	Past Impacts of Mine-Related and Community Pumping on N-Aquifer Wells, Stream Baseflows, and Springs, 2-Unit Operation
Historical impacts to N-Aquifer wells from mine-related pumping have been negligible to moderate. Community pumping also has generated historical drawdowns in N-Aquifer wells. Historical mine-related contributions to previous baseflow and spring impacts range from none to negligible. Past impacts on baseflows due to combined source effects range from none to moderate, depending on which channel is considered.	Historical impacts are the same as those described for the 3-Unit Operation.

Mine-related pumping has withdrawn water supplies from the N-Aquifer since the inception of mining in the 1970s. Pumping rates were greatest before 2006, when coal slurry deliveries to the Mojave Generating Station ceased. Mine-related drawdowns historically occurred at N-Aquifer wellfields. Since the cessation of pumping for the coal slurry pipeline at the end of 2005, water level recovery has occurred in some wells. These effects are detailed in **Appendix WR-9**, Attachment A. Community withdrawals also affect water levels in N-Aquifer wells. These community effects also are discussed and shown in **Appendix WR-9**, where the accompanying hydrographs indicate both mine-related and community pumping effects since 1970.

For N-Aquifer water supply wells with monitoring data, **Appendix WR-9**, Attachment A provides hydrographs showing measured and PWCC model simulated depth to water for 1) combined PWCC and community pumping and 2) community pumping only. These effects are scaled on the left-hand vertical axis of the hydrographs. Drawdown since 1970 due to PWCC mine-related pumping is given on the right-hand vertical axis of the hydrographs.

Well 4T-523 (Forest Lake NTUA1) is the community water supply well closest to the PWCC leasehold and exhibits the greatest effect of mine-related pumping on N-Aquifer water levels. As shown on **Appendix WR-9, Figure WR-9A.2**, the right-hand vertical axis indicates that up to about 220 feet of drawdown occurred in the well due to PWCC mine-related pumping between 1970 and roughly the end of 2005. After cessation of slurry pipeline-related pumping at the end of 2005, the water level has been recovering and is simulated to continue to recover through about 2028 (left-hand vertical axis). After 2029 the water level is expected to begin to decline again in response to the Proposed Action mine-related pumping and a projected future increase in Forest Lake community withdrawals. Once PWCC pumping stops completely in 2057, the simulated water level recovers slightly before continuing its decline due to the projected increase in Forest Lake withdrawals through 2110.

Combined PWCC and community pumping at Forest Lake NTUA1 increased the simulated depth to water from about 975 to about 1,215 feet bgs in Year 2006, as depicted on the left-hand vertical axis. This is a water level change (increased depth) of about 240 feet. Of that, approximately 20 feet of the increase was due to community pumping and about 220 feet was due to PWCC pumping. The top of the N-Aquifer screened interval at Forest Lake is 1,870 feet bgs, at the maximum drawdown due to PWCC pumping there was still 655 feet of water above the top N-Aquifer producing interval.

Other community wells show less effects of historical PWCC pumping. For example, at Pinon PM6 (**Appendix WR-9, Figure WR-9A.10**) the simulated maximum historic PWCC drawdown reached about 102 feet in about Year 2008. At Kayenta West (**Appendix WR-9, Figure WR-9A.4**), the maximum drawdown due to historic PWCC pumping was about 23 feet. The effects of mine-related pumping decrease logarithmically from the PWCC production wells on the leasehold. On the Hopi Reservation, the maximum drawdown due to mine related pumping was slightly over 16 feet in 2010 at Kykotsmovi (**Appendix WR-9, Figures WR-9A.7** and **WR-9A.8**).

At each of the foregoing wells (and all other N-Aquifer wells), the depth to water at the time of maximum mine-related drawdown is less than the predicted depth to water in 2110, as noted below. This is due to the projected increasing future demand, as provided by the tribes, for N-Aquifer water by the communities on Black Mesa. A listing of examples from **Appendix WR-9**, Attachment A follows, indicating their maximum simulated historical depths to water due to PWCC pumping, and their maximum projected future depths to water (from simulated combined PWCC and community pumping):

- Forest Lake NTUA1: 1,215 feet bgs (simulated historical maximum); 1,258 feet bgs (simulated future combined maximum);
- Pinon PM6: 672 feet bgs (simulated historical maximum); 959 feet bgs (simulated future combined maximum);
- Keams Canyon: 422 feet bgs (simulated historical maximum); 445 feet bgs (simulated future combined maximum).
- Kayenta West (8T-541): 310 feet bgs (simulated historical maximum); 455 feet bgs (simulated future combined maximum).

The impact of drawdown in water levels on an aquifer is measured by either a reduction in aquifer saturated thickness or by the cost of lifting water to the surface. As noted above, the well with the greatest mine-related drawdown (Forest Lake NTUA 1) remains fully saturated under maximum PWCC drawdown. The cost to produce water from a well, all other factors being equal, is directly proportional to the lift (depth to water) in the well. The increase in cost due to mine-related withdrawals can be approximated by the increase in lift caused by PWCC pumping. At Forest Lake NTUA 1 the maximum increase in lift due to PWCC pumping occurred in 2006 and was about 216 ft. This represented an increase in lift of 22 percent, a moderate impact, and well recovery has occurred since then. The maximum increase in lift at Pinon due to PWCC pumping was about 19 percent, in 2008, a moderate impact, and PWCC drawdown effects there are decreasing. At Kayenta West, the maximum percent increase in lift due to PWCC pumping was about 13 percent, in 2008, and PWCC drawdown effects are decreasing. At Keams Canyon 2, the maximum percent increase in lift due to PWCC pumping was about 13 percent, in 2010, and PWCC drawdown effects are decreasing. Small historical impacts occurred at other wells, and were negligible to minor.

As noted on **Table 3.7-15**, under the Proposed Action the maximum increase in lift going forward at Forest Lake is 3.1 percent and the maximum for all N-Aquifer community wells is 3.7 percent. These would be negligible future impacts.

Past combined pumping effects on stream baseflows are indicated in **Table 3.7-17**, based on modeling conducted for the EIS. Historical combined pumping effects are implied by the difference in flows (cfs) between 1956 and 2019. Historical combined pumping effects (mine-related plus community) on baseflows are estimated to range from almost zero (-0.24 percent on Moenkopi Wash), to over 20 percent on Polacca Wash (**Table 3.7-17**). Substantial parts of the estimated differences in baseflows are due to community pumping and evapotranspiration; mine-related pumping effects range from zero to about 6.3 percent of the estimated baseflow changes since 1956. Mine-related contributions to these impacts range from none to negligible on most channels. Baseflows on Polacca Wash depend substantially on D-Aquifer discharges to the stream. Mine-related impacts to Polacca Wash baseflows are negligible to minor.

- Scoping Concern: Past and future groundwater drawdown from mine-related pumping could have created (or would create) dessication cracks in the land surface and landslides along cliff edges in the Blue Gap area.

Past and Future Impacts from Fissures and Landslides Generated by N-Aquifer Pumping, 3-Unit Operation	Past and Future Impacts from Fissures and Landslides Generated by N-Aquifer Pumping, 2-Unit Operation
No fissures from mine-related groundwater pumping have occurred in the N-Aquifer study area. No impacts in the form of ground dessication cracks or landslides have occurred from past mine-related pumping, or would occur from proposed mine-related pumping. These features result in locations prone to them, from natural causes including extreme drought, erosion, and seismic activity.	Historical and potential impacts would be the same as those described for the 3-Unit Operation.

Mine-related pumping has withdrawn water supplies from the N-Aquifer since the inception of mining in the 1970s. Pumping rates were much greater before 2005, when coal slurry deliveries to the Mojave Generating Station ceased. Open surface dessication cracks (colloquially called “fissures”) and mass failures or “slips” on steep sideslopes have occurred in the Blue Gap area (within the cumulative effects study area) during the pumping period. Dessication features are occurring more extensively in Arizona, particularly in more clayey alluvial valleys such as Blue Gap, as a result of extended drought conditions (Harris 2004). Rather than N-Aquifer pumping, these features result from loss of moisture in the alluvial sediments due to drought. They are present elsewhere in Arizona in similar settings where no pumping has occurred (Harris 2004). The N-Aquifer rock matrix is not conducive to pumping subsidence. This is further addressed in Section 3.3, Geology and Landforms. There also has been fairly common recent seismic activity in the region, particularly along the Colorado River. These dessication cracks result from extreme drought acting on moisture conditions in silty and clayey alluvium. Natural factors (such as seismic activity and natural erosion at the toes and steep sideslopes of escarpments) have created mass failures and rock falls along the escarpment at the north end of the valley.

Mine-related pumping would continue in conjunction with community pumping from the N-Aquifer. Both activities would exist within a natural context of seismic events, cliff erosion, and periodic, lengthy droughts and climate change. These natural background conditions would create landslides and escarpment “retreat” along steep slopes and cliffs, and dessication cracks in clayey or silty alluvial valley deposits. Although these features do not result from mine-related N-Aquifer pumping, land surface dessication cracks and landslides would continue to result from natural background causes during an action alternative, or the No Action, and afterward. In the Blue Gap area, natural mass failures (with contributions from seismic events) are the major natural background causes of rock falls and landslides. Periodic lengthy droughts and the clayey and silty alluvial valley sediments have created the land surface dessication cracks in the Blue Gap area. No mine-related impacts have or would occur.

- Scoping Concern: Future groundwater drawdown from proposed mine-related pumping combined with projected community water supply withdrawals would create greater depths to water in N-Aquifer wells.

Impacts of Combined Mine-Related and Community Pumping on N-Aquifer Wells, 3-Unit Operation	Impacts of Combined Mine-Related and Community Pumping on N-Aquifer Wells, 2-Unit Operation
None to minor effects from mine-related pumping would occur. As described below (for the No Action Alternative), increasingly larger effects would result over time from projected community pumping.	Potential impacts would be the same as those described for the 3-Unit Operation.

The projected direct impact of pumping at the proposed KMC on water levels in the N-Aquifer community wells was described previously. Proposed Action mine-related pumping would remain relatively consistent through Year 2044 and then decline in stages, ending in 2057. Future community pumping will continue indefinitely. To assess the cumulative effects of both proposed mine-related pumping and projected future community pumping, it was necessary to develop a basis for estimating future community growth and water demand.

As discussed in the direct impacts assessment and in **Appendix WR-9**, the estimate of future water level change is supported by a numerical groundwater model of Black Mesa prepared for PWCC by Tetra Tech, Inc. (Tetra Tech 2014, Tetra Tech 2015a,b). The model has been reviewed by the USGS and determined to be suitable for use in predicting water level change in N-Aquifer wells within the model domain. Details of the model, the USGS review, and selected model files are presented in **Appendices WR-9** and **WR-10**. The PWCC model was run to estimate the time at which N-Aquifer water levels would cease to decline due to the Proposed Action mine-related pumping. This analysis predicted that maximum impacts due to that pumping would be reached prior to 2111 (Tetra Tech 2014). Based on this finding, community withdrawals were estimated through the year 2110.

The approach to estimating future community water demands was developed in coordination with the Navajo Nation, the Hopi Tribe, federal agencies, and project participants. The process and conclusions are described in a separate Technical Memorandum “Proposed Approach to Projecting Water Demands from N-Aquifer Groundwater Resources, Navajo Generating Station-Kayenta Mine Complex EIS, September 2014.” The basis of future community water demands are the assumptions that:

1. The average rate of population growth will be 1.3 percent compounded annually; and
2. The eventual maximum water demand (“target demand”) of 120 gallons per capita per day (gpcd) will occur at major growth centers.

Implementing this parameter set for input to the groundwater model included the following:

- The 2010 U.S. Census data (as adjusted for undercounts since 1990) is used as starting populations for each of the existing community well and distribution systems.
- The average pumping rate for the past 3 years (USGS pumping data) is used to calculate an initial pumping rate and a starting per capita demand (gpcd).
- The following community's demands ramp-up in equal 10-year increments from their initial pumping rates and demands (gpcd) beginning in 2010, achieving the 120 gpcd target demand in 2070 and remaining constant thereafter:
  - Tuba City;
  - Kayenta;
  - Pinon;
  - Moenkopi District;
  - Shonto; and
  - Polacca.
- Remaining existing communities ramp-up in equal 10-year increments from their initial pumping rates and demands (gpcd) beginning in 2010, to a final target demand of 100 gpcd in 2070 and remaining constant thereafter.
- Demands and population growth at "new" Hopi communities listed below are brought online in the years assumed and shown below, with the 120 gpcd target demand met at the outset:
  - Tawa'ovi: 2025, with initial population of 768;
  - Howell Mesa West, East: 2035, 2045, respectively, with initial populations of 768 each;
  - Spider Mound: 2060, with initial population of 432; and
  - South Oraibi: 2070, with initial population of 432.
- Hopi Arsenic Mitigation Project wells would be constructed and come online in 2020 and 2030 as currently existing Hopi high-arsenic wells are phased out.
- Pumping for the Many Mules project (approximately 300 acre-feet per year), which uses water produced from PWCC Well NAV2, starts in 2016.

The effect of the above community demands is to substantially increase the total groundwater withdrawn from the N-Aquifer during the model simulation period (through 2110). **Table 3.7-28** gives the annual withdrawals for key communities in 2011 and 2110 and the percent change.

Table 3.7-28 Community N-Aquifer Water Demands 2011 and 2110

Community	2011 Withdrawal (acre-feet per year)	Predicted 2110 Withdrawal (acre-feet per year)	% Change
Navajo			
Tuba City	1,162	4,751	309
Kayenta	441	3,188	623
Shonto	166	688	314
Dennehotso	60	1,207	1,912
Chilchinbito	64	498	678

Table 3.7-28 Community N-Aquifer Water Demands 2011 and 2110

Community	2011 Withdrawal (acre-feet per year)	Predicted 2110 Withdrawal (acre-feet per year)	% Change
Rough Rock	61	452	641
Forest Lake	15	120	700
Pinon	337	1,412	319
Hard Rock	50	476	852
Low Mountain	0	323	-
Shonto Junction	93	502	440
Red Lake	59	1,142	1,836
Rocky Ridge	6	49	717
Hopi			
Moenkopi	87	319	267
Hotevilla	25	154	516
Bacavi	24	154	542
Kykotsmovi	67	123	84
Hopi Civic Center	2	66	3,200
Shungopavi	38	51	34
Hopi Cultural Center	7	0 [1]	-
Polacca	185	0 [1]	**-**
Hopi High School	17	0 [1]	**-**
Keams Canyon	59	0 [1]	-
Mishongnovi	5	0 [1]	-
Second Mesa	7	0 [1]	-
HAMP[1]	0	1,508 [1]	-
Oraibi[2]	0	51	-
South Oraibi[2]	0	81	-
Spider Mound[2]	0	90	-
Howell Mesa[2]	0	190	-
Total	**3,037**	**17,595**	**479**

[1] Wells replace existing high arsenic wells at Hopi CC, Polacca, Mishonghovi, and Second Mesa in 2020 and Hopi HS, Keams Canyon in 2030.

[2] New (Future) Hopi Communities.

HAMP = Hopi Arsenic Mitigation Project.

As noted in **Table 3.7-28**, the total annual 2110 community groundwater withdrawal from the N-Aquifer is nearly six times the 2011 volume. This increase in pumping is accompanied by a decline in water levels in community wells. Since the growth in demand is driven by a compounding population growth rate, the maximum water level drawdown in wells generally occurs at the end of the projection period (i.e., 2110). The maximum projected N-Aquifer water level drawdown resulting from all proposed mine-related and community pumping is shown on **Figure 3.7-16**.

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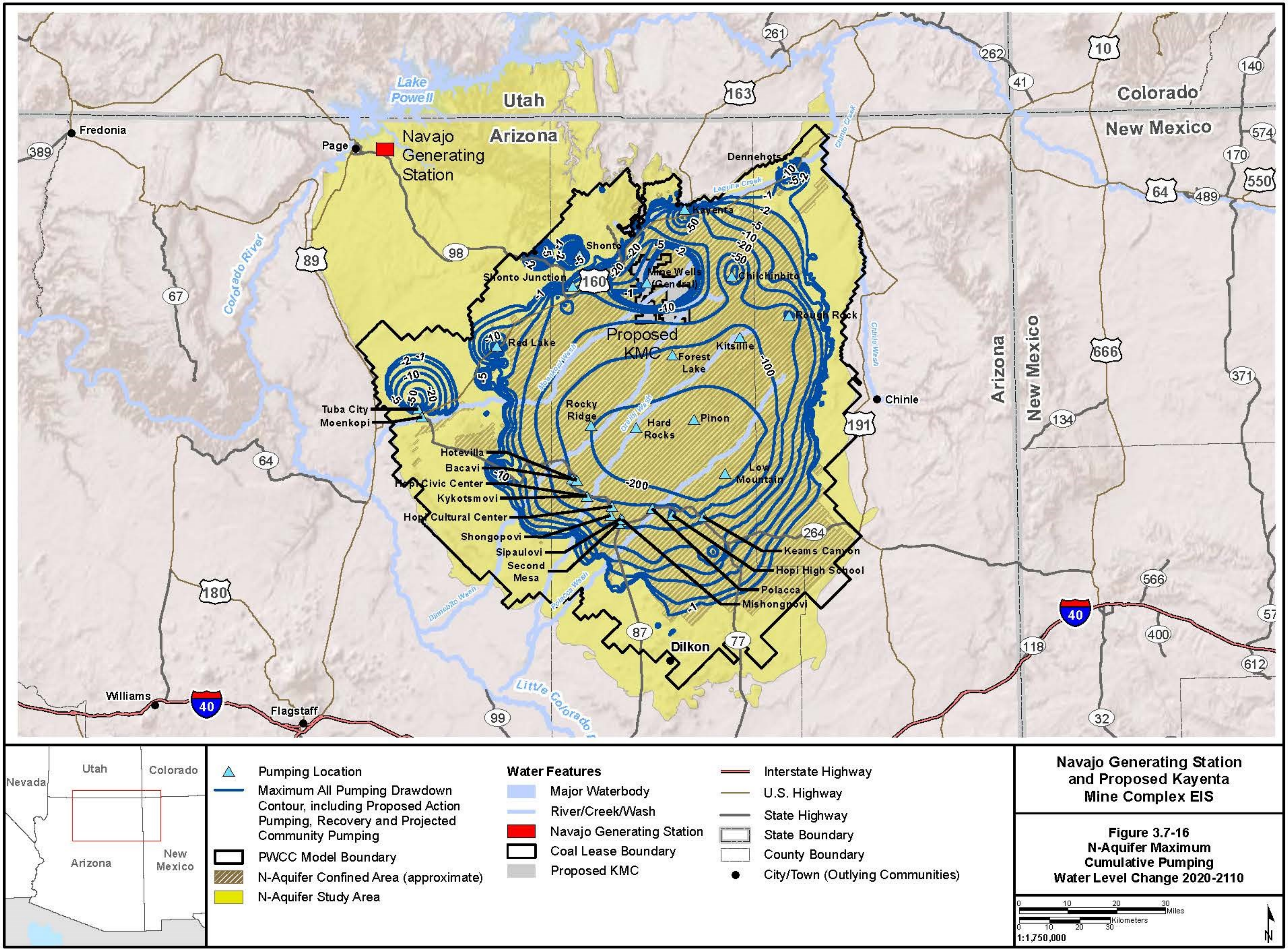

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure 3.7-16
N-Aquifer Maximum Cumulative Pumping Water Level Change 2020-2110

7/20/2016

To assess the portion of the cumulative effects created by Proposed Action mine-related pumping on community water supply wells, the separate increase in lift required to pump water to the surface due to planned PWCC pumping was distinguished from the predicted overall pumping water level resulting from combined community and project pumping. As discussed in the direct impacts text and previously shown in **Table 3.7-14,** the maximum drawdown in well water levels due to proposed mine-related pumping occurs at different years in different locations. To assess the relative impact of proposed PWCC pumping on key communities, the cumulative effects on depths to water (from both mining and community pumping), and the separate percent increases in lift due only to PWCC pumping were calculated for the year of maximum drawdown. The results of these calculations are given in **Table 3.7-29** below.

Table 3.7-29 Maximum Increase in Lift Due to Proposed Mine-Related Pumping During Combined Pumping Activities

Community	Proposed Action Maximum Year Depth to Water (feet bgs)[1]	No Action Alternative Maximum Year Depth to Water (feet bgs)	Increase in Lift Due to Mine-Related Pumping (PWCC Only) (%)
Navajo			
Kayenta	820	807	1.7
Shonto	375	375	0.0
Dennehotso	32	32	0.0
Chilchinbito	609	591	3.0
Rough Rock	727	724	0.3
Forest Lake	1,145	1,110	3.0
Pinon	898	882	1.7
Hard Rock	785	769	2.1
Shonto Junction	179	179	0.1
Red Lake	238	238	0.0
Rocky Ridge	599	587	2.0
Tuba City	210	210	0.0
Hopi			
Moenkopi	616	616	0.0
Hotevilla	1,002	999	0.3
Bacavi	1,024	1,021	0.3
Low Mountain	833	820	1.5
Kykotsmovi	280	277	0.9
Hopi Civic Center	440	437	0.6
Shungopavi	964	962	0.2
HAMP[2]	589	577	2.0

[1] Depth to water due to combined proposed PWCC and community pumping at year of maximum drawdown due to PWCC pumping (3-Unit Operation).

[2] Wells replace existing high arsenic wells at Hopi CC, Polacca, Mishongnovi, and Second Mesa in 2020, and Hopi HS and Keams Canyon in 2030; maximum depth to water occurs after 2030.

HAMP = Hopi Arsenic Mitigation Project.

As would be expected given its proximity to the proposed KMC leasehold, the maximum increase in lift due to the Proposed Action mine pumping occurs at Forest Lake. The range in percent increased lift at Black Mesa community wells varies from zero to 3 percent; the median value is 0.6 percent.

With respect to **Figure 3.7-16**, the maximum cumulative water-level change contours indicated on the figure would not occur everywhere at the same time. Similar to the previous discussion of **Figure 3.7-12**, the simulated maximum cumulative change contours are spatial in nature, but the timing of drawdown in the N-Aquifer would vary between specific locations. This is due to variations in pumping demands at different locations at different times, as well as the response of the aquifer to those demands. An additional factor in the simulated maximum cumulative water level change is that proposed pumping at the proposed KMC would cease in the year 2057, whereas the simulation period employed to identify groundwater effects extends to the year 2110. Because of this, proposed pumping in the coal lease area would cease more than 50 years before the end of the simulation period. Some recovery would occur in the leasehold locale as a result. At the same time, projected community demands on the aquifer would continue to increase.

Figure 3.7-16 depicts the maximum projected effects of the interaction between the proposed mine-related withdrawals and anticipated community withdrawals from the N-Aquifer. These could create negligible to severe impacts to the height of lift required to pump groundwater to the community water systems. As noted in **Table 3.7-28**, community withdrawals increase by a factor of nearly 6 times between 2011 and 2110. After mine-related pumping ceases in 2057, drawdown in areas affected by PWCC pumping will decrease (recover) while drawdown due to community pumping will increase over time due to the projected increase in population and resulting water use. This is evident in comparing drawdown contours on **Figure 3.7-16** to those on **Figure 3.7-15**, water level change due to PWCC pumping is limited to the confined area of the aquifer (**Figure 3.7-15**) while more drawdown in the unconfined aquifer in the area of Tuba City and Moenkopi can be seen in **Figure 3.7-16**, as a result of ongoing community withdrawals.

- Scoping Concern: Flow reductions at springs/seeps could occur from the combination of proposed mine-related pumping and community pumping (D- and N-Aquifers).

Impacts of Combined Mine-Related and Community Pumping on Springs, 3-Unit Operation	Impacts of Combined Mine-Related and Community Pumping on Springs, 2-Unit Operation
No change in flow at any of the USGS monitored springs is predicted as a result of the Proposed Action mine pumping under either the 3-Unit Operation or 2-Unit Operation. Negligible mine-related impacts are predicted at other D- or N-Aquifer springs. Thus, potential impacts at springs are predicted to result from cumulative increases in community pumping over time. These cumulative impacts would range from none to severe depending on hydrologic connections between springs and N-Aquifer wells.	Potential impacts would be the same as those described for the 3-Unit Operation.

Springs and seeps were grouped based on their geographic and hydrogeologic similarity. Spring and seep groups are shown previously on **Figure 3.7-14** and previously described in the assessment of direct impacts on springs. As with the potential direct impact of proposed PWCC pumping on springs, the PWCC 3-D groundwater flow model has been utilized to evaluate potential changes in flow at springs and seeps due to future community pumping. The PWCC groundwater flow model simulates the monitored springs using the MODFLOW Streamflow Routing Package (SFR2). The other non-monitored springs are represented by drain cells.

As previously discussed in the assessment of direct impacts on springs, the model simulated zero flow at the Moenkopi School and Burro Spring sites throughout the simulated period (1956-2110). This is thought to be due to complexities in the local geologic environment and the limitation of vertical discretization to simulate these complexities at these locations (Tetra Tech 2014, Tetra Tech 2015b).

Simulated cumulative effects on flow at the other two spring locations between 2019 and 2110 are given in **Table 3.7-30**.

Table 3.7-30 PWCC Model Simulated Spring Flow Cumulative Pumping Effects 2019 compared to 2110

Spring Name	2019 Simulated Flow (gpm)	2110 Simulated Flow (gpm)	% Change
Pasture Canyon	117	33.4	-71
Unnamed near Dennehotso	3.5	3.5	0

The change (reduction) in spring flow at Pasture Canyon is due to its proximity to Tuba City water supply wells. As noted in the direct impact section, no change in spring flow at the USGS monitored springs is predicted due to PWCC pumping under the Proposed Action. Changes in groundwater levels and discharge in the Pasture Canyon/Tuba City area are dominated by community pumping. The projected municipal pumpage at Tuba City ranges from 1,109 acre-feet per year in 2019 to 4,751 acre-feet per year in 2110, a fourfold increase. At Dennehotso, the percentage pumpage increase is greater than at Tuba City, but the 2110 volume is much smaller (1,207 acre-feet per year) and the pumping is further away from the spring. No change in flow at the Unnamed spring near Dennehotso is predicted due to combined PWCC and community pumpage. As noted in the assessment of direct impacts on springs, no change in flow at any of the USGS monitored springs is predicted as a result of the Proposed Action mine pumping under either the 3-Unit Operation or 2-Unit Operation. Thus, the impact to monitored springs is predicted to result from cumulative increases in community pumping over time. These cumulative impacts would range from none (Unnamed Spring near Dennehotso) to severe (Pasture Canyon), depending on withdrawal rates at N-Aquifer community pumping wells and their proximity and hydrologic connection to springs.

Due to model limitations, only 3 of the 98 simulated non-monitored springs produced a flow rate. The three flowing springs showed a decline in flow of 0.01, 0.02, and 3.48 gpm, respectively, between 1956 and 2110 due to combined Proposed Action and community pumping. The largest decline is at a spring located in Group D (see **Figure 3.7-14** presented previously), near the area of the Tuba City production wells, and represents a 60 percent decline (a severe impact). The other two springs are in Groups I and F1 and constitute a decline in flow of 1.5 and 3.0 percent, which are negligible impacts.

Since spring flow is proportional to change in head, to evaluate any potential change at the locations where the model predicted zero spring flow, the change in head (drawdown) due to Proposed Action and community pumping was noted. Model-predicted change in head at the simulated springs with zero flow ranged from zero to a maximum of approximately -39 feet; the median change is approximately -0.4 feet over the modeled period. These could create none to major cumulative impacts, depending on the spring location. The maximum predicted cumulative change-in-head impact would be in the Pasture Canyon area due to community pumping. This would be a major impact. The largest predicted impact from proposed PWCC pumping would be a head decline of 0.23 feet in the Blue Canyon area on Moenkopi Wash. This would be a negligible impact. Small cumulative drawdowns in the Shonto area (**Figure 3.7-16**) would likely create negligible spring impacts there.

The USGS regularly monitors flow at Moenkopi School Spring/Susunova Spring with a baseflow of approximately 10 to 20 gpm, or about 0.3 to 0.35 cfs. The model does not produce simulated flow at Moenkopi School Spring. The USGS describes the spring as “3GS-77-6, Navajo Sandstone tongue in Kayenta Formation” implying that locally the Navajo Sandstone connects to the spring within the Kayenta Formation (Littin 1992). As noted in the modeling report, in the model the Navajo is not present at the location, and the hydrogeologic characteristics of the Kayenta Formation are significantly different enough to make simulation of the observed flow rates impossible to match. The model represents the

Navajo Sandstone and the Kayenta Formation each as a single numerical model layer. This means that simulation of perched water, or water flowing in an isolated subunit is not possible to perform, as this would require subdivision of a model layer into at least 2 and probably 3 sub-layers. Spring discharge is expected to be directly tied to groundwater level at this location. A decrease in water levels would tend to cause a corresponding decrease in discharge at the spring. Although the model does not provide the ability to simulate flow at the location of the spring, simulated water levels in model layers 5 and 6 where these layers are active are likely to provide appropriate surrogate water level data for the purpose of evaluating the effects of pumping.

Between 1970 and 2012, the observed static water level elevation at Tuba City well NTUA1 (2.5 miles north) has declined by approximately 40 feet. Over the same time period, the model predicts a corresponding 53 feet of drawdown at the same well. All of this drawdown is due to local community pumping. Observed decreases in flow at the spring also are believed to be due exclusively to the drawdown associated with community pumping. In contrast, mine-related pumping effects at Tuba City N1 are simulated to be <0.01 feet in 2057 and 2110. Also, at the model cell associated with Moenkopi School Spring (model layer 6), mine-related pumping effects are simulated to be negligible (< 0.01 feet) by 2057 and 2110.

The USGS-observed baseflow from Burro Spring is approximately 0.2 to 0.4 gpm, or about 0.0004 to 0.0009 cfs. The location of Burro Spring is approximately 1,000 feet southeast of the Oraibi Wash channel, and approximately 75 to 100 feet higher in elevation. In aerial photos of the adjacent Oraibi Wash channel, the channel appears dry with some vegetation, suggesting that groundwater is likely present in the shallow alluvium of the channel. This means that flow occurring at Burro Spring is likely due to groundwater being locally perched on a layer within the Navajo Sandstone. As noted in the modeling report and for the reasons mentioned above, this condition is not possible to simulate within the framework of the model structure since the Navajo Sandstone is represented by a single numerical layer. Simulated drawdown at the model cell should represent an effective means of predicting spring discharge impacts at the location due to pumping, assuming that the water flow to the spring is directly linked to the regional N-Aquifer, and not solely a product of local recharge. No simulated drawdown occurs at the location of Burro Spring by 2057. By 2110, 0.09 feet of drawdown is simulated at the location of the spring, all of which is due to community pumping.

- Scoping Concern: Baseflow reductions along streams could occur from the combination of Proposed Action mine-related pumping and community groundwater pumping of the N-Aquifer.

Impacts of Combined Mine-Related and Community Pumping on Stream Baseflows, 3-Unit Operation	**Impacts of Combined Mine-Related and Community Pumping on Stream Baseflows, 2-Unit Operation**
Negligible mine-related baseflow impacts are predicted. Negligible to severe cumulative baseflow impacts are predicted, with the greatest estimated reductions along Chinle Creek, Laguna Creek, Polacca Wash, and Begashibito Wash.	Potential impacts would be the same as those described for the 3-Unit Operation.

As noted previously, the impact of proposed pumping at the proposed KMC on stream baseflow is assessed by a numerical model of Black Mesa prepared for PWCC by Tetra Tech, Inc. Baseflows are supported by groundwater discharge, and are important to the length of time that there is water in a channel during dry periods. The model was calibrated by simulating measured water levels and stream and spring flow from 1956 through 2012. Stream baseflow at eight locations is simulated using the MODFLOW Streamflow Routing Package (SFR2). The model has been reviewed by the USGS and determined to be suitable for use in predicting stream baseflow change within the model domain. Details of the model, the USGS review and model files are presented in **Appendices WR-9** and **WR-10**.

Simulated stream baseflow locations are shown on **Figure 3.7-13**. Simulated baseflow at the seven model locations were presented previously in **Table 3.7-17** for 1956 (pre-PWCC pumping) and 2019 (with PWCC pumping). As discussed previously, while the Proposed Action mine-related pumping stops in 2057, community pumping continues at a compounding annual rate indefinitely. In the model, community pumping is projected into the future through 2110. The increase in annual withdrawal by community wells in 2110 is nearly six times their estimated 2019 annual pumping rate.

The impact of all proposed mine-related pumping, windmill, and anticipated community withdrawals on simulated stream baseflow at the monitored stream gage locations between 1956 and 2019 was presented previously in **Table 3.7-17**. **Table 3.7-31** below presents additional information, showing the different components of pumping and their predicted effects on channel baseflows. For the Year 2110, the table identifies the anticipated effects of the mine-related Proposed Action pumping, projected community effects without mine-related pumping (i.e., the No Action), and also the anticipated cumulative effects of combined mine-related and projected community pumping (i.e., “All Pumping”).

Table 3.7-31 Simulated Baseflow End of 2019 Compared to 2110 Cumulative Pumping Effects (Combined Community and Proposed PWCC Pumping)

				Cumulative (Combined) Effects		**Community Pumping Only (No Action)**		**Proposed Action Only**	
Location[1]	**USGS Station No.**	**End of 2019 (cfs)**	**2110 (cfs)**	**Difference (cfs)**	**Percent Change from Year 2019[2]**	**Difference (cfs)**	**Percent Change from Year 2019[2]**	**Difference (cfs)**	**Percent Change from Year 2019[2]**
Moenkopi Wash	09401260	1.637	1.626	-0.011	-0.68	-0.0108	-0.66	-0.0004	-0.023
Dinnebito Wash	09401110	0.200	0.200	0.000	-0.06	-0.0001	-0.05	-0.0000	-0.012
Polacca Wash	09400568	0.098	0.067	-0. 031	-32.1	-0.0308	-31.4	-0.0007	-0.713
Chinle Creek	09379200	0.309	0.161	-0.147	-47.7	-0.1447	-46.8	-0.0027	-0.87
Jeddito Wash	09400583	0.062	0.061	-0.001	-2.05	-0.0012	-2.01	0.0000	-0.045
Begashibito Wash	NA	0.101	0.083	-0.018	-18.3	-0.0185	-18.3	0.0000	-0.030
Laguna Creek	09379180	0.326	0.186	-0.140	-43.0	-0.1375	-42.2	-0.0027	-0.827

[1] Locations are indicated on **Figure 3.7-13**.

[2] Arithmetic rounding effects: values shown reflect more decimal places available in the model outputs than are shown here for flow rate differences

cfs = flow rates in cubic feet per second.

NA – Not Applicable – No USGS gage at this location.

Source: Tetra Tech 2016.

The difference between the table values results from simulating all anticipated N-Aquifer pumping (PWCC, windmill, and community) from 2020 through 2110. Simulated total estimated withdrawal over this period is 1,002,983 acre-feet.

Over the same period, total PWCC 3-Unit Operation pumpage is predicted to be 32,500 acre-feet, or 3.2 percent of the total cumulative pumpage. As a result of the relatively small projected total withdrawal due to Proposed Action pumpage, negligible changes in 2110 stream baseflow due to mine-related pumping (3-Unit Operation or 2-Unit Operation) are predicted by the PWCC model. The majority of pumping effects on stream baseflows result from anticipated future community N-Aquifer pumping. The major baseflow declines due to non-project (primarily community) pumping effects and occur at Chinle Creek (46.8 percent), Laguna Creek (42.2 percent), Polacca Wash (31.4 percent), and Begashibito Wash (18.3 percent). These impacts would be major; impacts would be none to negligible at other locations.

- Scoping Concern: Cumulative proposed PWCC withdrawals combined with anticipated community pumping could reduce N-Aquifer water quality by increasing D-Aquifer leakage across the Carmel Formation.

Impacts of Combined Mine-Related and Community Pumping on Springs, 3-Unit Operation	Impacts of Combined Mine-Related and Community Pumping on Springs, 2-Unit Operation
Negligible cumulative effects on N-Aquifer water quality would result from combined pumping.	Potential impacts would be the same as those described for the 3-Unit Operation.

The potential for reduced N-Aquifer water quality (i.e., sulfate concentrations) in the N-Aquifer from cumulative pumping withdrawals also was analyzed for the EIS by simulation using the groundwater model. Results are presented in **Table 3.7-32** below. In general, there is little cumulative effect. The greatest potential impact is well east of the coal leasehold, south of Rough Rock in the Cottonwood locale just west of Chinle Wash. As can be seen by comparison with **Table 3.7-16**, these cumulative effects do not result from proposed mine-related activities. Based on these results, negligible cumulative effects on N-Aquifer water quality would result from combined pumping.

Table 3.7-32 Predicted Sulfate Concentration and Percentage Change due to All Combined Pumping (Community and Mine-Related) through 2110

Subarea	Initial Concentration (mg/L)		Predicted Final Concentration (mg/L)	Navajo Sandstone (% Change)
	D-Aquifer	Navajo Sandstone	Navajo Sandstone	
Northeast	250	70	71.095	1.5643
East	850	100	117.734	17.7340
Hopi Buttes	360	50	51.888	3.7760
Forest Lake	1,000	100	100.354	0.3543
Kits’illie	75	30	30.025	0.0838
Pinon	200	5	5.150	2.9954
Rocky Ridge	250	10	10.159	1.5879
Preston Mesa	400	10	10.000	0.0017
Leasehold	400	30	30.079	0.2631
Pinon to Kits’illie	1,000	20	20.571	2.8573
Surrounding Leasehold	100	45	4.5015	0.0322
Red Lake to Tuba City	400	50	50.154	0.3075
Hotevilla to Kabeto	200	35	35.358	1.0229
Pinon to Rocky Ridge	210	140	140.083	0.0590

Source: Tetra Tech 2015a.

3.7.4.2.5.4 Past Effects on Wepo Formation Water Levels, Water Quality, and Uses

- Scoping Concern: Long-term mining activities have reduced water levels and water quality in the Wepo Formation.

Impacts of Combined Mine-Related and Community Pumping on Springs, 3-Unit Operation	Impacts of Combined Mine-Related and Community Pumping on Springs, 2-Unit Operation
Long-term effects on Wepo aquifer water levels have varied in relation to the configurations of local water-bearing zones and hydraulic gradients with respect to those of mine pits and topography. These impacts are limited in extent, and would only affect some wells in or near the leasehold. Impacts of water quality changes have been negligible within the coal resource areas. Elsewhere on Black Mesa, springs and wells supplied from the Wepo Formation have not been affected by mining activities.	Impacts have not differed from the 3-Unit Operation.

Limited interception of Wepo Formation groundwater has already occurred during PWCC mining at existing coal resource areas (OSMRE 2011a). Long-term groundwater levels in Wepo Formation monitoring wells display a mix of rises and declines. Most of the wells in the northwest part of the leasehold, where mining activity has been extensive, have declined over time. Similarly, in the eastern part of the leasehold, water levels at WEPO62R near the J16 mined area have declined. In contrast, levels in monitoring wells WEPO44, 49, 54, and 59 along Moenkopi Wash have remained within their baseline ranges or have risen. Wepo aquifer water levels in the J19/J21 coal resource vicinity display a mix of declines (at WEPO65, 68) and fairly steady levels (at WEPO 66, 67). Although nearby pits drain groundwater from higher elevations, it appears that relatively porous pit backfills generally have not contributed to increasing downgradient water levels in tighter, consolidated formation rocks.

As described in the Affected Environment section and **Appendix WR-5**, the Wepo Formation consists of various rock types that formed from a variety of depositional environments. These individual zones have limited local extent, and form perched, or isolated water bearing zones. Many of these zones are pressurized. Groundwater elevation contours and gradients generally follow significant surface topography. As discussed previously, major washes and canyons intersect the formation and further hydraulically isolate one part of the formation from another.

Long-term effects on Wepo aquifer water levels have varied in relation to the configurations of local water-bearing zones and hydraulic gradients with respect to those of mine pits and topography. This would continue under a Proposed Action option. Given the geologic nature of the formation, cumulative water level declines in the Wepo Formation could not extend more than 3 to 5 miles beyond a mine pit. Given the dissected topography of Black Mesa, it is unlikely that detectable drawdown effects could extend more than a mile or so outside the leasehold. In some cases, this may have created drawdown within water-bearing zones beyond the leasehold. However, most drawdown effects in the Wepo Formation are probably much less extensive. Particularly from upgradient areas northeast of the leasehold, the overall flow direction is to the southwest towards the mining activities. As a result, cumulative drawdown probably has been less extensive to the northeast. Springs or wells that are sourced from the Wepo Formation beyond about 3 to 5 miles from the leasehold, or from isolated upgradient positions closer in, have not been affected by mining activities.

Yellow Water Canyon Wash, Coal Mine Wash, Moenkopi Wash, and Dinnebito Wash all intersect the Wepo Formation and allow it to drain to surface water and alluvial deposits. Dinnebito Wash in particular restricts cumulative drawdown effects from extending further east. Elsewhere on Black Mesa, springs and wells supplied from the Wepo Formation have not been affected by mining activities. These outlying springs and wells have their sources in local, isolated Wepo Formation water-bearing zones, or are supplied from the Toreva Formation. The Toreva Formation is below the zone being mined by PWCC and is not affected by mining activity. These conditions would continue to apply to Wepo and Toreva formation groundwater resources if a Proposed Action option was implemented.

Long-term water quality characteristics of Wepo Formation monitoring wells are summarized in **Appendix WR-5**, **Tables WR-5.8** through **WR-5.12**. Trace element constituents had fairly low values in background wells as indicated in **Appendix WR-5, Table WR-5.8**. Dissolved lead had some presence, but typical values are below the surface water criterion for livestock watering. TDS concentrations were reasonable for the geologic conditions; there was a relatively low proportion of sulfate and relatively higher proportions of bicarbonate and sodium.

In the northwest part of the leasehold (**Appendix WR-5, Table WR-5.9**), most trace elements remained undetected or at low values in Wepo monitoring wells. Lead concentrations were elevated above those of background wells, and occasionally exceeded the surface water criterion for livestock watering. Typical lead concentrations were below the criterion, however. Sulfate was elevated above background conditions, as were bicarbonate, calcium, and magnesium. In general, these contributed to higher TDS values. Typical sulfate and TDS values remained within surface water criteria for livestock watering.

Elsewhere, groundwater quality conditions generally similar to these also are reflected in summaries for the northeast/east central part of the leasehold (**Appendix WR-5, Table WR-5.10**) and the former Black Mesa Mine area (**Appendix WR-5, Table WR-5.12**). Sodium and selenium concentrations were greater in Wepo monitoring wells in the former Black Mesa Mine area. On average, detected selenium concentrations exceeded the surface water criterion for livestock watering there, but most values were below the criterion. Selenium was detected in only 7 percent of Wepo Formation samples in the former Black Mesa Mine Area.

Historical water quality reductions from long-term mining activities have occurred, but concentrations have generally remained within livestock watering criteria or recommended values. Some springs or seeps issuing from the Wepo Formation downgradient of mining activities may have become more mineralized, but remain within background water quality ranges at springs within the leasehold. Existing Wepo aquifer groundwater quality typically continues to support aquatic and wildlife uses at springs.

Impacts of these changes have been negligible within these coal resource areas. Groundwater from Wepo aquifer wells has generally remained within livestock watering criteria or recommended values. Some springs or seeps issuing from the Wepo Formation downgradient of proposed mining activities may have become more mineralized, but remains within background spring water quality ranges. Future Wepo aquifer groundwater quality would provide aquatic and wildlife uses at springs, and permanent ponds and impoundments would provide other habitat. Based on the geography of these sampling results, the past extent of reduced groundwater quality in the locale was likely limited to part of the leasehold west of Dinnebito Wash and a short distance downstream. The extent of past mining is relatively small in the Dinnebito Wash watershed, and a substantial amount of undisturbed Wepo Aquifer remains in and around the leasehold. The uses of Wepo aquifer groundwater in this vicinity have been infrequent and are likely to remain so. These factors limit the extent of historical cumulative impact to a comparatively small area with little use of groundwater. Because of this, impacts would be negligible.

Over time, the establishment of permanent ponds and impoundments by PWCC has mitigated adverse impacts on local uses of Wepo Aquifer groundwater for habitat or livestock along Dinnebito Wash. These impacts and their mitigation would continue under either the 3-Unit Operation or the 2-Unit Operation.

3.7.4.2.5.5 Cumulative Effects on Alluvial Water Levels, Water Quality, and Uses

- Scoping Concern: In the past, historic mining activities have reduced alluvial groundwater levels in and near the leasehold. Alluvial groundwater availability has been reduced for other uses downstream on Black Mesa in the past, and the Proposed Action would add to these impacts in the future.

Impacts of Combined Mine-Related and Community Pumping on Springs, 3-Unit Operation	Impacts of Combined Mine-Related and Community Pumping on Springs, 2-Unit Operation
Mixed rises and declines in alluvial water levels have occurred within the leasehold over time. Generally these are negligible effects. Based on comparisons to early data at sites away from mining activities, drier climate conditions have had a substantial role in alluvial water level declines.	Potential impacts would be the same as those described for the 3-Unit Operation.

Alluvial groundwater levels are characterized over time in **Appendix WR-4**, **Table WR-4.1**. Only one alluvial well, ALUV87, has strictly baseline water level data, but several others have data from early periods that overlap baseline conditions and initial mining activities. Monitoring site ALUV87 is on the mainstem of Moenkopi Wash, well upstream of mining activities (**Appendix WR-1, Figure WR-1.1**). It is located in the east-central corner of the leasehold, 1 mile or more upstream of any mining activity.

Water levels in ALUV87 have been gradually declining since the early 1980s, most likely in response to the drier climatic period described in the Affected Environment. During the baseline period water levels ranged from 14.2 to 22.5 feet bgs. Since 2010, water levels have stayed in the lower part of that range (generally below about 20 feet) or slightly deeper. In 2014, the water level in ALUV87 was 23.7 feet bgs (**Appendix WR-4, Table WR-4.1**). The general pattern of deepening alluvial water levels also can be seen in ALUV108R. ALUV108R is on Dinnebito Wash upstream of mining activities. Although it does not have data from the early baseline period, since 2010 its water level has dropped between 3.3 and 5 feet below its deepest value during the late 1980s/early 1990s. Closer to likely mining effects, some of the alluvial wells with relatively early water level data have experienced recent declines of about 0.8 foot (ALUV72) to 5.4 feet (ALUV19) from the 1980s. The maximum decline has been 9 feet (ALUV93). In contrast, other alluvial water levels that are likely subject to mining effects have risen from their lowest early levels, such as at ALUV29 (5 feet) and ALUV83 (6 feet).

In summary, mixed rises and declines in alluvial water levels have occurred within the leasehold over time. Declines appear to dominate the water level changes; in general these are negligible effects. Based on comparisons to early data at sites away from mining activities, drier climate conditions have had a substantial role in water level declines.

As described for direct impacts, there are little or no existing uses of alluvial groundwater within the leasehold and nearby. The only other major use of alluvial groundwater is far downstream at Moenkopi, where withdrawals are used for agriculture. No effects to those uses would occur under a 3-Unit Operation or 2-Unit Operation. Alluvial groundwater levels much further downstream are affected by local precipitation and runoff there, as well as by local channel conditions and withdrawals. The downstream conditions reflect regional climatic changes, the thickness and types of materials comprising the channels, contributions from local aquifer discharges, and evapotranspiration. No regional effects from mining have or would occur to alluvial groundwater levels at distances far downstream of the leasehold.

- Scoping Concern: Long-term mining activities have reduced regional alluvial water quality and limited uses of alluvial groundwater.

Impacts of Combined Mine-Related and Community Pumping on Springs, 3-Unit Operation	Impacts of Combined Mine-Related and Community Pumping on Springs, 2-Unit Operation
Both upstream and downstream concentrations of TDS and sulfate exceed concentrations recommended in literature for livestock. Some alluvial groundwater quality impacts would occur across the leasehold, but constituents would still generally reflect the background geologic setting. These would be minor impacts. For most trace elements, cumulative impacts to alluvial groundwater quality would not occur.	Potential impacts would be the same as those described for the 3-Unit Operation

Alluvial groundwater quality declines from upstream to downstream across the leasehold as indicated in long-term monitoring data summaries (**Appendix WR-4**, **Tables WR-4.9** through **WR-4.12**). Dissolved trace element concentrations are typically low, and many are below detection limits in most samples. For example, dissolved arsenic was not detected in 83 out of 86 samples (96 percent) upstream on Moenkopi Wash (**Appendix WR-4, Table WR-4.11**). For most trace elements, cumulative impacts to alluvial groundwater quality would not occur.

In upstream to downstream comparisons of long-term data for Moenkopi Wash, mercury, arsenic, and other trace element values remained low across the leasehold (**Appendix WR-4, Tables WR-4.11** and **WR-4.12**). Vanadium concentrations declined. In contrast, selenium concentrations increased downstream, as did typical TDS values. Typical sulfate values also increased somewhat downstream. On Dinnebito Wash, most trace elements were undetected or had very low concentrations over the long term (**Appendix WR-4, Tables WR-4.9** and **WR-4.10**). Selenium was detected more frequently and at higher concentrations in downstream samples, but still remained well below the livestock watering criterion. Dissolved lead values increased downstream, and exceeded the livestock watering criterion at least once. However, lead was only detected in 4 out of 64 long-term samples downstream (6 percent). Similar to Moenkopi Wash comparisons, typical TDS and sulfate values increased downstream on Dinnebito Wash. These changes are depicted further in **Table 3.7-33** below.

Tables in **Appendix WR-4** show that both upstream and downstream concentrations of TDS and sulfate exceed concentrations recommended in literature for livestock watering (Raisbeck et al. 2008; Sigler and Kleehammer 2013).

Table 3.7-33 Major Water Quality Changes in Long-term Alluvial Groundwater Monitoring

Drainage within Leasehold	Median TDS Values, Upstream / Downstream (mg/L)	Median TDS Values, Upstream to Downstream (Percent Change)	Median Sulfate Values, Upstream / Downstream (mg/L)	Median Sulfate Values, Upstream to Downstream (Percent Change)
Moenkopi Wash	3,125 / 4,154	33	1,885 / 2,586	37
Dinnebito Wash	4,350 / 6,409	47	2,800 / 3,900	39

With respect to long-term (past) impacts in and near the leasehold, however, livestock watering from alluvial groundwater is uncommon and PWCC has historically mitigated potential losses of this use with additional ponds and impoundments. Substantial additional downstream watershed areas on both Moenkopi Wash and Dinnebito Wash reduce the regional influence of mining activities to none or negligible levels, well upstream of irrigated agriculture or other significant uses. Cumulative impacts from reduced alluvial groundwater quality would not occur from either the 3-Unit Operation or 2-Unit Operation.

3.7.4.2.5.6 Past Impacts to Shallow Springs and Seeps

- Scoping Concern: Historic mining activities have reduced flows at springs and seeps issuing from the alluvium or the Wepo Formation on Black Mesa in the past, and the Proposed Action would add to these impacts.

Impacts of Combined Mine-Related and Community Pumping on Springs, 3-Unit Operation	Impacts of Combined Mine-Related and Community Pumping on Springs, 2-Unit Operation
None to negligible long-term mining effects to alluvial or Wepo Formation springs have occurred outside the leasehold. PWCC has mitigated impacts to springs and seeps by replacing them on the leasehold by permanent ponds and impoundments	Potential impacts would be the same as those described for the 3-Unit Operation.

Relatively shallow springs and seeps are those from the Wepo Formation or, to a more limited degree, alluvial deposits in and along streams. Impacts to shallow springs and seeps from mining activities have been limited to within the leasehold, or at most within a mile or so downgradient of its boundaries. These impacts are described further in groundwater assessments for the alluvium and the Wepo Formation below. More extensive impacts to shallow springs and seeps would not occur.

PWCC has mitigated impacts to springs and seeps by replacing them on the leasehold by permanent ponds and impoundments. These structures typically provide better water availability and water quality. Elsewhere on Black Mesa, springs and wells supplied from the Wepo Formation have not been affected by mining activities. These outlying springs and wells have their sources in local, isolated Wepo Formation water-bearing zones (**Appendix WR-5**), or are otherwise supplied from the Toreva Formation. The Toreva Formation is below the zone being mined by PWCC and is not affected by mining activity.

3.7.4.2.5.7 Potential Cumulative Impacts to Surface Flows on Moenkopi Wash or Dinnebito Wash

- Scoping Concern: In the past, stream runoff and baseflows retained in ponds and impoundments on the coal leasehold may have reduced the availability of surface water for other users at locations far downstream, and the Proposed Action could continue to do so in the future.

Impacts of Combined Mine-Related and Outlying Retention on Streamflows, 3-Unit Operation	Impacts of Combined Mine-Related and Outlying Retention on Streamflows, 2-Unit Operation
Downstream channel flow impacts (reductions) from water retention in the coal leasehold would not occur. Impacts to channel flows from outlying structures or activities would be none to moderate, depending on location and nature of the diversions.	Potential impacts would be the same as those described for the 3-Unit Operation.

As identified during scoping meetings, there are concerns that expansion of mining areas under either the 3-Unit Operation or 2-Unit Operation have the potential to reduce flows needed for other uses (agriculture, livestock watering) at downstream locations along Moenkopi Wash or Dinnebito Wash. This potential exists because water resulting from runoff, purge water from well testing, and pit pumping has been and would be retained in ponds and impoundments to control the water quality of disturbed area discharges. These management practices are conducted by PWCC in response to USEPA and OSMRE regulatory programs. By retaining surface flows in the mine area, there are concerns that downstream uses along Moenkopi Wash and Dinnebito Wash have been and could be impacted by reduced water volumes. These designated uses include agricultural irrigation, aquatic and wildlife habitat, livestock watering, full body contact, partial body contact, and groundwater recharge (**Appendix WR-1**). Given that these uses occur in different locations along the lower washes, they also are affected by other retention or withdrawals at different locations along Moenkopi and Dinnebito washes.

Because of numerous non-mining runoff controls on Dinnebito Wash, and interactions between surface water, alluvial sands, and irrigation sumps on lower Moenkopi Wash, the potential for these structures and activities to interact with mine-related effects on the lower washes has been reviewed as part of cumulative water controls and uses. These combined factors, in conjunction with natural background conditions (e.g., evapotranspiration, channel seepage), are reflected in flow records at the identified streamgages on the lower washes. The proportions of these factors cannot be quantified with available information, but downstream structures and activities outside the leasehold do have an effect on flows at the gages.

There are at least 20 diversion or retention structures along Dinnebito Wash outside of the leasehold. These non-mining uses (runoff diversions, pond storage) also have the potential to affect downstream flows, e.g., at the USGS streamgage near Sand Springs (USGS 09401110). In addition, scoping inputs reflect concerns at the Village of Moenkopi, where conditions can be represented by the USGS streamgage there (USGS 09401260). Hand-dug pits are used for agricultural diversion sumps in the channel alluvium in that locale.

In the arid setting, most of the runoff from the leasehold does not contribute to flow at the USGS gages or to designated uses further downstream, due to channel transmission losses and evapotranspiration along the way. In addition, baseflows are provided by the Toreva Formation and other geologic units that are not affected by mining. Notably, approximately 70 miles of meandering sand channel extend across the arid landscape from the leasehold to the first occurrence of irrigated agriculture near the community of Moenkopi. At the downstream edge of the leasehold, PWCC gages monitor about 253 square miles of watershed. The USGS gage downstream at the community of Moenkopi monitors about 1,629 square miles. Based on contemporaneous monitoring at leasehold stations on Moenkopi Wash, and the USGS stream gage at Moenkopi, PWCC has demonstrated substantial channel losses between the two locations. Even when assuming that no lateral inflows would have occurred between the monitoring sites, PWCC estimates that approximately 50 percent or more of the runoff from the leasehold can be lost in transit to the USGS gage; in some cases, much more seeped into the channel. This is a very conservative (low) assumption, since lateral inflows do occur due to the occurrence of rainfall between the stations during large storms.

Due to losses of runoff in transit and the substantial variability of precipitation across the watersheds, little or no impacts from PWCC retention structures occur to existing uses at Moenkopi. A similar assessment applies along Dinnebito Wash to Sand Springs, where the downstream leasehold gages monitor about 51 square miles of watershed, and the USGS gage monitors about 473 square miles. Because of these considerations, no mine-related cumulative impacts on downstream surface water runoff, baseflows, or uses would occur. Depending on the nature and location of a downstream structure or activity, effects from non-mining features further downstream are likely to have none to moderate effects on stream flows.

3.7.4.2.5.8 Potential Cumulative Impacts to Surface Water Quality

- Scoping Concern: In the past, reduced surface water quality flowing from the coal leasehold may have adversely impacted downstream uses and conditions, and these impacts would continue under the Proposed Action.

Impacts of Mine-related Water Quality Effects on Downstream Uses, 3-Unit Operation	Impacts of Mine-related Water Quality Effects on Downstream Uses, 2-Unit Operation
Due to natural background conditions and extensive downstream contributing watersheds, distant water quality impacts from the leasehold drainage area have been and would be none to negligible.	Potential impacts would be the same as those described for the 3-Unit Operation.

High rates of erosion and sediment transport are typical of the region, as mentioned in the Affected Environment. Sediment yields were previously modeled by PWCC using the SEDIMOT II application, which in its various forms has been an approved pond design tool for several decades. Subsequent reclamation planning and design efforts have used the EASI model (PWCC 2012 et seq.). PWCC siltation structures and other retention designs meet or exceed applicable requirements. Comparing the pre-mining estimates to the post-mining, reclaimed estimates indicates that at final reclamation, sediment yields from disturbed areas should be slightly less than the original condition (PWCC 2012 et seq.). Other Best Management Practices for runoff and wastewater control and drainage are employed at the proposed KMC in accordance with NPDES permit provisions. Based on ongoing application of approved structural and non-structural management practices, and additional programs implemented by PWCC in response to USEPA involvement, no cumulative impacts from accelerated sediment yields outside of the leasehold would occur with either the 3-Unit Operation or 2-Unit Operation.

To further examine conditions over past historical periods, additional long-term surface water quality characterizations were completed for both Moenkopi Wash and Dinnebito Wash, upstream and downstream of PWCC coal resource areas. Data from 1985 through 2005 were used on Dinnebito Wash, and data from 1981 to 2008 were used on Moenkopi Wash. On both washes, these efforts reviewed sampling events that were reasonably matched together with respect to upstream and downstream sample timing. Data results are summarized in **Appendix WR-1, Tables WR-1.17** through **WR-1.20**, and discussed further below.

On Moenkopi Wash, the following qualitative long-term (1981 through 2008) concentration changes from upstream to downstream are summarized from the surface water quality data review. While the constituents listed in **Table 3.7-34** do not comprise the entire suite of laboratory analyses, they include the ones of most interest with respect to existing designated uses.

Table 3.7-34 Moenkopi Wash Long-term Water Quality Comparisons, Upstream to Downstream within the Leasehold

Constituent [1]	Percent Non-Detected, Downstream	Qualitative Change toward Downstream, Remaining Detected Values [2]	Constituent [1]	Percent Non-Detected, Downstream	Qualitative Change toward Downstream, Remaining Detected Values [2]
Aluminum (t)	6.2	Little or None	Iron (t)	5.4	Decrease
Arsenic (t)	25	Increase	Lead (t)	34	Decrease
Arsenic (d)	73	Decrease	Lead (d)	90	Increase
Cadmium (t)	73	Mixed	Mercury (t)	72	Slight Increase
Cadmium (d)	92	Increase	Selenium (t)	50	Slight Decrease

Table 3.7-34 Moenkopi Wash Long-term Water Quality Comparisons, Upstream to Downstream within the Leasehold

Constituent [1]	Percent Non-Detected, Downstream	Qualitative Change toward Downstream, Remaining Detected Values [2]	Constituent [1]	Percent Non-Detected, Downstream	Qualitative Change toward Downstream, Remaining Detected Values [2]
Chromium (t)	28	Slight Increase	TDS	0	Large Increase
Chromium (d)	98	Increase	TSS	3.9	Large Decrease
Copper (t)	15.6	Little or None	Sulfate	0	Large Increase
Copper (d)	80	Decrease	Vanadium (t)	11	Little or none

[1] Reference **Appendix WR-1**, **Tables WR-1.17** and **WR-1.18**.

[2] Qualitative descriptions of changes are based on comparing average and median values, as changes from upstream to downstream.

t = total.

d = dissolved.

While these are qualitative conclusions, in general there was fairly consistent long-term trace element chemistry from upstream to downstream along Moenkopi Wash across the leasehold. While some total constituent values increased, their dissolved fractions decreased or a large portion of the analyses were below detection limits. In some cases (“Mixed”), the changes between average concentrations differed from the changes in median concentrations. Although detected values in some constituents increased downstream (e.g., lead), these constituents were not detected in large percentages of the long-term sampling results. The most notable impacts from data presented in the summary tables in **Appendix WR-1** are substantial long-term increases in typical TDS and sulfate values in the downstream direction, and a substantial decrease in long-term TSS downstream. The latter effect is likely due to PWCC water management practices, and would generally be considered an ongoing beneficial impact. Increases in TDS and sulfate concentrations were likely caused by a combination of mine water management and some background contributions, and would be an ongoing localized impact within the leasehold as described for direct impacts. Although the TDS and sulfate values increased downstream, their typical concentrations remained within recommended livestock watering values (Raisbeck et al. 2008; Sigler and Kleehammer 2013) and are likely to continue to support that use. Sulfate and TDS criteria for aquatic and wildlife uses were met by median concentrations upstream, but were exceeded by median concentrations downstream. Since these would be localized impacts, and background conditions elsewhere on the mesa are generally similar, mine-related impacts to overall watershed conditions would be none to negligible.

Downstream along Moenkopi Wash, all of these constituents have been and would be further contributed by lateral channel inflows and runoff from additional watershed areas that are not affected by mining. Surface water quality more than a few miles downstream of the leasehold reflect influences from local runoff and baseflows from nearby geologic sources. On much of Black Mesa, the latter primarily include the Wepo and Toreva formations, Mancos Shale, and the D-Aquifer formations (**Figure 3.7-4**). Historical USGS downstream sampling along Moenkopi Wash had typical sulfate values of 642 mg/L (mean) and 315 mg/L (median). TDS concentrations had average and median values of 1,147 and 680 mg/L, respectively. A Hopi Tribal sample at the Blue Canyon water caves in June 2009 had a sulfate concentration of 201 mg/L, and a TDS value of 550 mg/L. In August 2007, a tribal sample there had a sulfate result of 580 mg/L and a TDS value of 980 mg/L. These are not out of line with concentrations on Moenkopi Wash at the downstream side of the coal leasehold. There are 253 square miles in the leasehold drainage area for Moenkopi Wash, only part of which are affected (see **Table 3.7-22** for a general concept). Because of regional contributions from a far larger undisturbed watershed

(1,629 square miles at Moenkopi), more distant water quality impacts from the leasehold drainage area have been and would be none to negligible.

On Dinnebito Wash, the following qualitative long-term (1985 through 2005) concentration changes from upstream to downstream are summarized in **Table 3.7-35** from the surface water quality data review. Again, the constituents listed do not comprise the entire suite of laboratory analyses, but are of most interest in regard to designated uses.

Table 3.7-35 Dinnebito Wash Long-term Water Quality Comparisons, Upstream to Downstream within the Leasehold

Constituent [1]	Percent Non-Detected, Downstream	Qualitative Change toward Downstream, Remaining Detected Values [2]	Constituent [1]	Percent Non-Detected, Downstream	Qualitative Change toward Downstream, Remaining Detected Values [2]
Aluminum (t)	0	Increase	Iron (t)	0	Mixed
Arsenic (t)	4.5	Large Decrease	Lead (t)	32	Large Increase
Arsenic (d)	47	Little or None	Lead (d)	92	Large Increase
Cadmium (t)	73	Mixed	Mercury (t)	50	Large Increase
Cadmium (d)	100	Little or None	Selenium (t)	27	Decrease
Chromium (t)	9.1	Increase	TDS	0	Large Decrease
Chromium (d)	100	Little or None	TSS	0	Large Increase
Copper (t)	0	Mixed	Sulfate	0	Large Decrease
Copper (d)	93	Little or None	Vanadium (t)	0	Mixed

[1] Reference **Appendix WR-1**, **Tables WR-1.19** and **WR-1.20**.

[2] Qualitative descriptions of changes are based on comparing average and median values, as changes from upstream to downstream.

t = total.

d = dissolved.

Long-term surface water quality across the leasehold in Dinnebito Wash appears to behave differently than that in Moenkopi Wash. Some trace element concentrations typically did not increase or decrease substantially in a downstream direction. In some cases (“Mixed”), the changes between average concentrations differed from the changes in median concentrations. Along Dinnebito Wash, typical detected long-term lead concentrations were well above standards upstream above mining activities, and increase further downstream through the leasehold. Typical mercury values behaved similarly. However, both lead and mercury remained below detection limits in large portions of samples. Lead and mercury concentrations were not detected in 92 percent and 50 percent of long-term sampling results, respectively. Typical long-term vanadium concentrations exceeded standards upstream. They declined downstream, but still exceeded standards.

Typical long-term sulfate and TDS values declined downstream along Dinnebito Wash, whereas typical long-term TSS values increased. For TDS, sulfate, and TSS, these are opposite to the water quality effects on Moenkopi Wash. Similar to Moenkopi Wash conditions, however, livestock water uses are generally supported by typical TDS and sulfate values when compared to recommended values (Raisbeck et al. 2008; Sigler and Kleehammer 2013). Typical sulfate, TDS, and TSS values exceeded aquatic and wildlife habitat criteria both upstream of mining activity on Dinnebito Wash and downstream through the leasehold. Because of these results and the nature of upstream background surface water quality in the overall mesa area, mine-related impacts would be none to negligible. There are 51 square miles in the leasehold drainage area for Dinnebito Wash, only part of which are affected (see **Table 3.7-22** for a general concept). Background conditions in the larger watershed (e.g., 473 square miles at Sand Springs) would contribute water quality constituents to surface flows. Because of regional contributions, downstream water quality impacts from the leasehold drainage area have been and would be none to negligible.

3.7.4.2.5.9 Cumulative Impacts Along Transmission Lines

- Scoping Concern: Water quality in streams crossed by transmission lines could be reduced by construction or maintenance activities in the ROWs.

As previously described, no direct impacts to water resources would occur along either transmission system as a result of the Proposed Action or action alternatives; similarly, no cumulative impacts would occur. Existing operation and maintenance practices (**Appendix 1B**), agency ROW requirements, and any additional requirements that may stem from future ROW agency approval processes, would avoid or mitigate direct project impacts to water resources along the transmission systems. Therefore, there would be no cumulative or additive impacts associated with the transmission systems from the Proposed Action, an alternative, or No Action.

3.7.4.3 Natural Gas Partial Federal Replacement Alternative

This discussion is divided into two parts. The first part describes assumptions about the alternative electrical supply site and operational characteristics and primary water resources impacts that have occurred or would occur. The second part addresses the impacts to water resources from reducing the power generated at NGS, with consequent reductions in coal production at the Kayenta Mine.

Under the Natural Gas Partial Federal Replacement (PFR) Alternative, a selected quantity of power between 100 megawatts (MW) and 250 MW would be contracted for under a long-term power purchase agreement from currently unidentified, existing natural gas generation sources, displacing an equivalent amount of power from the federal share of NGS generation. Because the facility is unknown but assumed to currently exist, prior disturbance impacts to water resources are not evaluated. The following list presents key assumptions about water resources related to an existing natural gas-fueled, electrical power-generating plant. Based on these characteristics, future water resources impacts at such a site would be none to negligible. The following water management-related aspects of such a facility are listed below.

- A combined-cycle natural gas power plant would typically be located on a dry, upland site of approximately 100 acres. No additional surface disturbance would be required over time.
- Existing natural gas pipelines to the facility, and transmission lines from the facility would have been constructed, operated, and maintained in accordance with applicable agency ROW permit stipulations and construction storm water permit requirements (including a Storm Water Pollution Prevention Plan), federal floodplain requirements (Executive Order 11988/13690), and hydraulic considerations for channel scour and bank migration at stream crossings.
- An SPCC Plan has been implemented and maintained to prevent, or respond to and report, spills or leaks of petroleum products. Operations and maintenance activities are conducted in compliance with a current industrial NPDES permit, with attendant Storm Water Pollution Prevention Plan.
- All water used for potable or sanitary uses and for other operational uses (e.g., testing of valves or pipelines, dust suppression at the plant site and access roads, etc.) has been obtained through existing water rights. Any depletions have been approved and mitigated if necessary through applicable agency requirements and approvals.
- Only non-hazardous materials are disposed of in landfills on the site.

- Natural gas combustion to generate power would not result in deposition to surface water of the trace elements associated with coal combustion under the Proposed Action. This difference in emissions is addressed in Section 3.1.

Impact issues for this PFR alternative are discussed across the range of NGS unit operations (3-Unit and 2-Unit) and associated alternative power reductions (100 MW and 250 MW) from the least NGS power reduction to the greatest. Reductions in NGS power generation would proportionally reduce the quantity of coal delivered from the Kayenta Mine. The focus of this discussion is to distinguish differences in impacts within the operational range of the alternative to provide a basis for comparison with the Proposed Action.

3.7.4.3.1 Navajo Generating Station

The following topics discuss potential impacts water resources if 100 MW to 250 MW of power generation were replaced at NGS. Under this alternative, alternative power would be purchased from an unknown, but existing source of electrical power generated with natural gas. It should be noted that decommissioning and reclamation practices are summarized in **Appendix 1B** and its supplemental Groundwater Protection Plan. These are both included as part of the EIS. Importantly, the Groundwater Protection Plan addresses water resources monitoring and protection at the NGS in accordance with federal regulations. For the Proposed Action, for all alternatives, and for the No Action, discussions of particular NGS considerations (e.g., ash disposal, potential spills or leaks, decommissioning and post-closure monitoring) take into account the past, present and future activities that have been conducted and would be conducted by SRP at the plant. These are further documented in the Operations Groundwater Protection Plan, and would be continually developed and implemented in ongoing NGS programs.

3.7.4.3.1.1 Impacts to Surface Water or Groundwater Quantity or Quality from Dry Ash Disposal

Additional disposal of dry coal combustion products in the existing ash disposal area would not affect runoff volumes or water quality in the study area. The ash is deposited as a dry or nearly dry material in an arid environment. If an expanded ash disposal area were required, its acreage would be small (on the order of 40 acres or so) and would not affect surface water. Groundwater is not used at the plant or at the ash disposal site. Water in the N-Aquifer is hundreds of feet below the disposal area, and existing monitoring has shown no impacts from the facility. Ongoing groundwater monitoring would document and report any aquifer effects if they occurred. USEPA agency oversight continues, and regulatory actions would be implemented in the highly unlikely event that groundwater quality would be affected.

Closure and post-closure activities at the ash disposal landfill would be planned and implemented according to accepted professional engineering practices in accordance with the Groundwater Protection Plan and Coal Combustion Residuals Rule. As with the Proposed Action, additional runoff and run-on control features and other practices to protect water resources would be implemented in accordance with agency requirements. Groundwater monitoring and site inspections are part of existing site management by SRP. These would continue with under the Natural Gas PFR Alternative, in accordance with USEPA regulatory programs (Coal Combustion Residuals Rule) and the NGS-specific Groundwater Protection Plan. Additional descriptions of activities that would be planned, implemented, and monitored are presented in Appendices B and C of **Appendix 1B** and mentioned in the “No Action” discussion (Section 3.7.4.6 below).

With respect to water resources, the Groundwater Protection Plan developed in response to the CCR Rule would be the primary guidance document for water-related decommissioning work. Additional specific component planning, implementation, and monitoring would be completed by SRP, and would include coordination with appropriate agencies (e.g., USEPA, Navajo Nation authorities). Lease requirements and USEPA regulations at the time of closure would be used as the basis for specific implementation of plant decommissioning procedures and practices, including those at the ash disposal area. Because of these factors, no impacts to water resources at the dry ash disposal area would occur.

3.7.4.3.1.2 Impacts to Surface Water or Groundwater from Spills or Leaks at Fluid Storage or Evaporation Ponds

No water resources impacts would occur from uses of existing ponds under continued operations and maintenance, and agency-approved inspection and monitoring programs. If any new ponds are needed, impacts to water resources would be avoided by appropriate design and construction, monitoring, and maintenance. Under this alternative, NGS would continue to operate and maintain perched water monitoring and recovery to address leaks isolated under the plant area. No impacts to water quality in the N-Aquifer would occur.

Similar to the Proposed Action, water management under this alternative would include practices and procedures described in the Groundwater Protection Plan. These would include continued implementation of the Perched Water Dewatering Work Plan (**Appendix 1B**). Because of ongoing recovery and discharge of leaks to the plant process water stream, no impacts to the N-Aquifer would occur under this alternative.

Closure and post-closure activities for ponds would be planned and implemented according to accepted professional engineering practices. No water resources impacts would occur.

3.7.4.3.1.3 Effects of Water Withdrawals for NGS on Water Levels and Surface Area of Lake Powell

Estimated potential changes in water level and reservoir extent are indicated in **Table 3.7-36** below. Water use estimates are pro-rated (based on power generation and units operated) from the Proposed Action values.

Table 3.7-36 Estimated Direct Effects of Natural Gas PFR Water Withdrawals on Lake Powell

Typical Water Use[1]	Reservoir Status	Typical 100-MW PFR Annual Water Use (acre-feet per year)	Predicted 100-MW PFR Water Level Reduction (inches)	Predicted 100-MW PFR Lake Area Reduction (acres)	Typical 250-MW PFR Annual Water Use (acre-feet per year)	Predicted 250-MW PFR Water Level Reduction (inches)	Predicted 250-MW PFR Lake Area Reduction (acres)
NGS 3-Unit Operation	Normal Pool	27,840	2.1	131.4	25,230	1.9	119.1
	Extreme Drought	27,840	4.5	166.1	25,230	4.1	150.6
NGS 2-Unit Operation	Normal Pool	17.986	1.4	84.9	16,052	1.2	75.8
	Extreme Drought	17.986	2.9	107.3	16,052	2.6	95.8

[1] Tabulated values reflect arithmetic rounding differences and interpolation from existing Lake Powell data.

Source: Reclamation 2009, 2007.

As can be seen in the table above, differences between the Natural Gas PFR operating alternatives are not substantial in relation to the overall reservoir characteristics described in the Affected Environment. Differences from a respective Proposed Action effect at the listed reservoir condition (full pool or drought) also are negligible. Direct impacts from the Natural Gas PFR at NGS would be negligible.

3.7.4.3.1.4 Effects of Airborne Deposition of Trace Elements on Water Quality within a 20-km Radius of the Station

Estimated airborne deposition of trace elements (arsenic, mercury, and selenium) for the Natural Gas PFR is described in Chapter 2.0 and the Air Quality section. Proportional reductions in emissions from the Proposed Action are anticipated under this alternative. Because of this, proportional reductions of deposited concentrations also are anticipated from NGS under this alternative. Since only negligible effects would occur from NGS under the Proposed Action, impacts under the Natural Gas PFR also would be negligible. Negligible direct effects would occur in the Near-field study area, the southwest gap area (Colorado River below Lake Powell) and in the northeast gap area (Colorado River above Lake Powell). Negligible direct effects also would occur along the San Juan River study area.

3.7.4.3.2 Proposed Kayenta Mine Complex

Under the Natural Gas PFR, it is assumed that all proposed coal areas will be mined, but at a lower rate and on a modified schedule compared to the Proposed Action. For the 3-Unit Operation, coal production is estimated to range between 7.135 million tons per year (tpy) to 7.714 tpy, compared to 8.100 million tpy for the Proposed Action 3-Unit Operation. For the 2-Unit Operation, coal production is estimated to range between 4.535 million tpy to 5.114 million tpy, compared to 5.500 million tpy for the Proposed Action 2-Unit Operation. The extent of mine-related surface disturbance could be modified by proportional changes from the Proposed Action, as estimated in **Table 3.7-37**.

Table 3.7-37 Proposed KMC Surface Disturbance Estimates, Proposed Action Compared to the Natural Gas PFR Alternative

NGS Operation	Proposed Action Disturbance (acres)	Natural Gas PFR, 100-MW Disturbance (acres)	Natural Gas PFR, 250-MW Disturbance (acres)
NGS 3-Unit	5,230	4,968	4,602
NGS 2-Unit	4,741	4,409	3,888

3.7.4.3.2.1 Effects of Mine-related Pumping on N-Aquifer Groundwater Levels and Quality

Since mining activities and the overall extent of supporting components (e.g., access roads) would be the same as or similar to those for the Proposed Action, mine-related rates of groundwater withdrawals from the N-Aquifer are assumed not to change. Because of this, the Natural Gas PFR would generate minor mine-related effects on N-Aquifer water levels and negligible effects on groundwater quality. Direct effects would be the same as described for the Proposed Action.

3.7.4.3.2.2 Effects of Mine-related N-Aquifer Pumping on Springs, Seeps, and Stream Baseflows

Mine-related rates of groundwater withdrawals from the N-Aquifer are assumed not to change. Because of this, the Natural Gas PFR would generate none to negligible mine-related effects on springs, seeps and stream baseflows associated with N-Aquifer sources. Direct effects would be the same as described for the Proposed Action.

3.7.4.3.2.3 Effects of Mining Activities on Groundwater Levels and Water Quality in the Wepo Formation, Alluvial Aquifers, and Related Shallow Springs and Seeps

Similar to the Proposed Action, groundwater levels and water quality in these shallower aquifers would be affected by variations in natural background conditions such as precipitation rates, localized recharge, and geologic characteristics. Negligible impacts to water levels would result. Concentrations of water quality constituents such as sulfate and TDS would increase in areas affected by mining, but would remain within those standards or recommended values that have been used as benchmarks. These effects would be slightly less than described for a comparable Proposed Action operation, due to the decrease in new mining disturbance under a Natural Gas PFR. Localized minor water quality impacts would result. Existing surface water uses (habitat and livestock watering) are not generally supplied by access to shallow groundwater. Ongoing availability of supplies from PWCC ponds and impoundments would continue to support these uses in and near the leasehold.

3.7.4.3.2.4 Effects of Mining Activities on Surface Water Flows and Water Quality in Streams and Ponds

New mining disturbance would be somewhat less than in a comparable Proposed Action operation, as depicted in **Table 3.7-37** above. Because of this, the amount of surface water draining to and retained in temporary ponds may slightly decline from Proposed Action estimates. Whether or not less water would be retained would depend on specific mine configurations that are not currently known. Due to downstream lateral inflows and high background rates of evapotranspiration and channel seepage, effects downstream of the leasehold would be none to negligible. As with a Proposed Action operation, surface water quality would be maintained by continuing mine water management programs. These would include sediment retention, reclamation and best management practices to control erosion and runoff, and monitoring and mitigation. Existing water uses (habitat and livestock watering) would not be affected, due to ongoing availability of supplies from PWCC ponds and impoundments.

3.7.4.3.3 Transmission Systems and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

The potential impacts to water resources, and the approaches to operations and maintenance that would avoid such impacts, would be the same as those described for the Proposed Action. By conducting activities within appropriate guidelines and complying with permit approvals and conditions, no impacts to water resources would occur.

3.7.4.3.4 Project Impact Summary – All Project Components

Based on the assumptions for this alternative, there would be slightly less effects on Lake Powell water levels and extent than under a Proposed Action operation. The overall impacts to lake extent and water level would be negligible. Differences from a respective Proposed Action operation would be negligible. Somewhat less trace element deposition (for arsenic, mercury, and selenium) from NGS emissions would occur, relative to a comparable power generation rate from a Proposed Action operation. This would reduce the potential NGS impacts to surface water quality from a Natural Gas PFR to negligible levels.

Mine-related N-Aquifer impacts at the Proposed KMC would be the same as those from the Proposed Action. Impacts to groundwater levels and quality in shallow aquifers on the leasehold would be the same or slightly less than in a comparable Proposed Action, due to a reduction in new mining disturbance and the potential for corresponding changes in mine configurations. Similarly, potential surface water impacts would be the same or slightly less than a comparable Proposed Action operation. Existing water uses for livestock and habitat would be maintained the same as under the Proposed Action, due to continuing access to PWCC ponds and impoundments.

3.7.4.3.5 Cumulative Impacts

The cumulative actions and resource considerations for the Natural Gas PFR Alternative parallel those listed and described for the Proposed Action.

3.7.4.3.5.1 Navajo Generating Station

Effects of Cumulative Water Withdrawals on Water Level and Surface Area of Lake Powell

Potential cumulative impacts could result from combined withdrawals from Lake Powell, including those from NGS and the proposed Lake Powell Pipeline Project. Other included water projects (LTEMP and the San Juan Pipeline) would not create cumulative impacts from water withdrawals, as was described for the Proposed Action. Estimated potential cumulative changes in water levels and reservoir extents are indicated in **Table 3.7-38** below.

Table 3.7-38 Estimated Cumulative Effects of Natural Gas PFR Water Withdrawals and Lake Powell Pipeline Project on Lake Powell

Typical Water Use[1]	Reservoir Status	Typical 100-MW Annual Water Use (acre-feet per year)	Predicted 100-MW Water Level Reduction (inches)	Predicted 100-MW Lake Area Reduction (acres)	Typical 250-MW Annual Water Use (acre-feet per year)	Predicted 250-MW Water Level Reduction (inches)	Predicted 250-MW Lake Area Reduction (acres)
NGS 3-Unit Operation and Lake Powell Pipeline	Normal Pool	27,840 + 86,250	8.5	573.1	25,230 + 86,250	8.3	526.1
	Extreme Drought	27,840 + 86,250	18.6	681.7	25,230 + 86,250	18.2	666.2
NGS 2-Unit Operation and Lake Powell Pipeline	Normal Pool	17,986 + 86,250	7.8	491.9	16,052 + 86,250	7.6	591.4
	Extreme Drought	17,986 + 86,250	17.0	622.9	16,052 + 86,250	16.7	611.4

[1] Tabulated values reflect arithmetic rounding differences and interpolation from existing Lake Powell data.

Source: Reclamation 2009, 2007; Washington County Water Conservancy District 2016.

As can be seen from the table above, potential cumulative withdrawals would have a more substantial effect on the water level and surface area of Lake Powell than NGS withdrawals alone. These would be negligible to minor impacts. Differences between these estimated cumulative Natural Gas PFR changes and those of a comparable cumulative Proposed Action operation are negligible.

Effects of Cumulative Airborne Deposition of Trace Elements on Water Quality within the Overall Surface Water Study Area

The very small contributions of selected trace elements (arsenic, mercury, selenium) predicted for the Proposed Action would be reduced in NGS emissions from this alternative. Other cumulative contributions would not change, so impacts to surface water quality in the Colorado River, Lake Powell, and the San Juan River would be very similar to cumulative impacts described for a corresponding Proposed Action operation. Negligible water quality impacts would occur in Lake Powell and along the upstream and downstream sections of the Colorado River. Minor to moderate water quality impacts would occur along the San Juan River.

Past and Present Effects of Water Management at NGS on N-Aquifer Groundwater Quality

As described previously in the Affected Environment discussion, a zone of perched water occurs at shallow depths below the NGS plant area. This water results from small leaks at plant components such in the cooling tower area, from previously unlined ponds, and some drainage ditches. A perched water recovery, monitoring, and reporting program was previously established and implemented in coordination with the USEPA to address conditions at the plant. This would be a continuing activity under the Natural Gas PFR Alternative. No past or present impacts to N-Aquifer water quality have occurred.

3.7.4.3.5.2 Proposed Kayenta Mine Complex

Cumulative effects at the KMC could result from mine-related N-Aquifer pumping combined with projected community pumping. In addition, concerns have been expressed that retention of surface water at the proposed KMC could reduce water availability for other uses at distances far downstream of the coal leasehold. Such uses could involve agriculture along Moenkopi Wash, retention for livestock watering downstream on Dinnebito Wash, or others. Other cumulative impact considerations at the proposed KMC would parallel those described for the Proposed Action.

Cumulative Effects on N-Aquifer Water Levels and Groundwater Quality

Since combined N-Aquifer pumping rates under this alternative would be the same as those for the Proposed Action, potential cumulative impacts would be the same. Minor to moderate effects on N-Aquifer water levels would occur, and negligible impacts to N-Aquifer water quality would occur.

Effects of Combined Community and Mine-related Pumping on N-Aquifer Springs, Seeps, and Stream Baseflows

Since combined N-Aquifer pumping rates under this alternative would be the same as those for the Proposed Action, potential cumulative impacts would be the same as for the Proposed Action. Minor to moderate drawdown would occur in the N-Aquifer wells. Discharges at some N-Aquifer springs would be reduced by minor amounts, whereas none to negligible effects would occur at others. Cumulative declines in N-Aquifer contributions to stream baseflows would be negligible to major, depending on the stream location.

Effects of Mining Activities on Surface Water Flows for Cumulative Downstream Uses

These impacts would be the same as described for the Proposed Action. Since pumping for the Natural Gas PFR would have none to negligible effects on surface water flows from the leasehold and have none to negligible effect on channel flows at USGS gages further downstream on Moenkopi Wash or Dinnebito Wash, there would be no cumulative effects on distant cumulative downstream uses under this alternative.

3.7.4.3.5.3 Transmission Systems and Communication Sites

No cumulative impacts to water resources would occur, assuming that transmission line operations and maintenance would comply with regulatory permit requirements and applicable agency ROW stipulations related to water resource features.

3.7.4.4 Renewable Partial Federal Replacement Alternative

Under the Renewable PFR Alternative, a selected quantity of power between 100 MW and 250 MW would be contracted for under a long-term power purchase agreement from a currently unidentified, existing renewable energy power source, displacing an equivalent amount of power from the federal share of NGS generation. As the site is assumed to be an existing facility, prior disturbance impacts to water resources are not evaluated.

This discussion is divided into two parts. The first part describes assumptions about the alternative electrical supply site and operational characteristics and primary water resources impacts that have occurred or would occur. The second part addresses the impacts to water resources from reducing the power generated at NGS, with consequent reductions in coal production at the Kayenta Mine.

This alternative assumes that an existing source of power from renewable energy would be used to reduce (curtail) NGS 3-Unit Operation or 2-Unit Operation by 100 MW to 250 MW of electricity. Because the facility is unknown but assumed to currently exist, prior disturbance impacts to water resources are not evaluated. The following list presents key assumptions about water resources related to an existing renewable energy-fueled electrical power generating plant. Based on these characteristics, future water resources impacts at such a site would be none to negligible. The following water management-related aspects of such a facility are assumed:

- A renewable energy power plant would typically be located on a dry, upland site of approximately 100 acres. No additional surface disturbance would be required over time.
- Existing transmission lines from the facility, would have been constructed, operated, and maintained in accordance with applicable agency ROW permit stipulations and construction storm water permit requirements (including a Storm Water Pollution Prevention Plan), federal floodplain requirements (Executive Order 11988/13690), and hydraulic considerations for channel scour and bank migration at stream crossings.
- An SPCC Plan has been implemented and maintained to prevent, or respond to and report, spills or leaks of petroleum products. Operations and maintenance activities are conducted in compliance with a current industrial NPDES permit, with attendant Storm Water Pollution Prevention Plan.
- All water used for potable or sanitary uses and for other operational uses (e.g., dust suppression at the plant site and access roads, etc.) has been obtained through existing water rights. Any depletions have been approved and mitigated if necessary through applicable agency requirements and approvals.
- Only non-hazardous materials are disposed of in landfills on the site.
- The renewable energy source that generates power would not result in deposition to surface water of the trace elements associated with coal combustion under the Proposed Action. This difference in emissions is addressed in the Air Quality resource section.

Impact issues for this PFR alternative are discussed across the range of NGS unit operations (3-Unit and 2-Unit) and associated alternative power reductions (100 MW and 250 MW) from the least NGS power reduction to the greatest. Reductions in NGS power generation would proportionally reduce the quantity of coal delivered from the Kayenta Mine. The focus of this discussion is to distinguish differences in impacts within the operational range of the alternative to provide a basis for comparison with the Proposed Action.

3.7.4.4.1 Navajo Generating Station

The following topics discuss potential impacts water resources if 100 MW to 250 MW of power generation were replaced at NGS. Under this alternative, alternative power would be purchased from an existing, renewable source of electrical power generation.

3.7.4.4.1.1 Impacts to Surface Water or Groundwater Quantity or Quality from Dry Ash Disposal

Potential impact considerations would be similar to those described for the Natural Gas PFR and the Proposed Action, 2-Unit Operation. Because of these factors, no impacts to water resources at the dry ash disposal area would occur.

3.7.4.4.1.2 Impacts to Surface Water or Groundwater from Spills or Leaks at Fluid Storage or Evaporation Ponds

Potential impact considerations would be similar to those described for the Natural Gas PFR. No water resources impacts would occur. Similar to the Proposed Action and the Natural Gas PFR, water management under this alternative would include practices and procedures described in the Groundwater Protection Plan. These would include continued implementation of the Perched Water Dewatering Plan (**Appendix 1B**) and the Groundwater Monitoring Plan both included in **Appendix 1B**. Because of ongoing recovery and discharge of leaks to the plant process water stream, no impacts to the N-Aquifer would occur under this alternative. As with the Proposed Action and alternatives, groundwater protection and related monitoring would avoid or mitigate water resources impacts at NGS under this alternative.

3.7.4.4.1.3 Effects of Water Withdrawals for NGS on Water Levels and Surface Area of Lake Powell

Potential impact considerations would be similar to those described for the Natural Gas PFR. Negligible water resources impacts would occur.

3.7.4.4.1.4 Effects of Airborne Deposition of Trace Elements on Water Quality within a 20-km Radius of the Station

Potential impact considerations would be similar to those described for the Natural Gas PFR. Negligible water resources impacts would occur.

3.7.4.4.2 Proposed Kayenta Mine Complex

Under the Renewable PFR, it is assumed that all proposed coal areas will be mined, but at a lower rate and on a modified schedule compared to the Proposed Action. For the 3-Unit Operation, coal production is estimated to range between 7.537 million tpy to 7.875 million tpy, compared to 8.100 million tpy for the Proposed Action 3-Unit Operation. For the 2-Unit Operation, coal production is estimated to range between 4.937 million tpy to 5.275 million tpy, compared to 5.500 million tpy for the Proposed Action 2-Unit Operation. The extent of mine-related surface disturbance could be modified by proportional changes from the Proposed Action, as estimated in **Table 3.7-39**.

Table 3.7-39 Proposed KMC Surface Disturbance Estimates, Proposed Action Compared to the Renewable PFR Alternative

NGS Operation	Proposed Action Disturbance (acres)	Renewable PFR, 100-MW Disturbance (acres)	Renewable PFR, 250-MW Disturbance (acres)
NGS 3-Unit	5,230	5,072	4,863
NGS 2-Unit	4,741	4,551	4,267

3.7.4.4.2.1 Effects of Mine-related Pumping on N-Aquifer Groundwater Levels and Quality

Potential impact considerations would be similar to those described for the Natural Gas PFR. Because of this, the Renewable PFR would generate minor mine-related effects on N-Aquifer water levels and negligible effects on groundwater quality.

3.7.4.4.2.2 Effects of Mine-related N-Aquifer Pumping on Springs, Seeps, and Stream Baseflows

Mine-related rates of groundwater withdrawals from the N-Aquifer are assumed not to change. Because of this, the Renewable PFR would generate none to negligible mine-related effects on springs, seeps and stream baseflows associated with N-Aquifer sources.

3.7.4.4.2.3 Effects of Mining Activities on Groundwater Levels and Water Quality in the Wepo Formation, Alluvial Aquifers, and Related Shallow Springs and Seeps

Groundwater levels and water quality in these shallower aquifers would be affected by variations in natural background conditions. Negligible impacts to water levels would result. Water quality effects would be slightly less than described for a comparable Proposed Action operation, due to the decrease in new mining disturbance under a Renewable PFR. Localized minor water quality impacts would result. Ongoing availability of supplies from PWCC ponds and impoundments would continue to support these livestock and wildlife uses in and near the leasehold.

3.7.4.4.2.4 Effects of Mining Activities on Surface Water Flows and Water Quality in Streams and Ponds

New mining disturbance would be somewhat less than in a comparable Proposed Action operation, as depicted in **Table 3.7-39** above. Impact considerations would be the same as those described for the Natural Gas PFR. Due to downstream lateral inflows and high background rates of evapotranspiration and channel seepage, effects downstream of the leasehold would be none to negligible. Surface water quality would be maintained by continuing mine water management programs, with none to negligible impacts. Existing water uses (habitat and livestock watering) would not be affected, due to ongoing availability of supplies from PWCC ponds and impoundments.

3.7.4.4.3 Transmission Systems and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

3.7.4.4.4 Project Impact Summary – All Project Components

Based on the assumptions for this alternative, there would be slightly less effects on Lake Powell water levels and extent than under a Proposed Action operation. There would be none to negligible differences between the Renewable PFR and the Natural Gas PFR. The overall impacts to lake extent and water level would be negligible. Differences from a respective Proposed Action operation would be negligible. Somewhat less trace element deposition (for arsenic, mercury, and selenium) from NGS emissions would occur, relative to a comparable power generation rate from a Proposed Action operation. This would reduce the potential NGS impacts to surface water quality from a Renewable PFR to negligible levels. Transmission line impacts would be none, similar to the Natural Gas PFR.

Mine-related N-Aquifer impacts at the Proposed KMC would be the same as those from the Proposed Action. Impacts to groundwater levels and quality in shallow aquifers on the leasehold would be the same or slightly less than in a comparable Proposed Action, due to a reduction in new mining disturbance and the potential for corresponding changes in mine configurations. Similarly, potential surface water impacts would be the same or slightly less than a comparable Proposed Action operation. Existing water uses for livestock and habitat would be maintained the same as under the Proposed Action, due to continuing access to PWCC ponds and impoundments.

3.7.4.4.5 Cumulative Impacts

The cumulative actions and considerations for this alternative parallel those for the Proposed Action and Natural Gas PFR Alternative.

3.7.4.4.5.1 Navajo Generating Station

Effects of Cumulative Water Withdrawals on Water Level and Surface Area of Lake Powell

Potential cumulative withdrawal effects would be very similar to those tabulated for the Proposed Action and Natural Gas PFR. Cumulative withdrawals would have a more substantial effect on the water level and surface area of Lake Powell than NGS withdrawals alone. These would be negligible to minor impacts. Differences between the estimated cumulative Renewable PFR changes and those of a comparable cumulative Proposed Action operation would be negligible.

Effects of Cumulative Airborne Deposition of Trace Elements on Water Quality within the Overall Surface Water Study Area

The very small contributions of selected trace elements (arsenic, mercury, selenium) predicted for the Proposed Action would be reduced in NGS emissions from this alternative. Other cumulative contributions would not change, so impacts to surface water quality in the Colorado River, Lake Powell, and the San Juan River would be very similar to cumulative impacts described for a corresponding Proposed Action operation. Negligible water quality impacts would occur in Lake Powell and along the upstream and downstream sections of the Colorado River. Minor to moderate water quality impacts would occur along the San Juan River.

Past and Present Effects of Water Management at NGS on N-Aquifer Groundwater Quality

As described previously in the Affected Environment discussion, a zone of perched water occurs at shallow depths below the NGS plant area. This water results from small leaks at plant components such in the cooling tower area, from previously unlined ponds, and some drainage ditches. A perched water recovery, monitoring, and reporting program was previously established and implemented in coordination with the USEPA to address conditions at the plant. This would be a continuing activity under the Natural Gas PFR Alternative. No past or present impacts to N-Aquifer water quality have occurred.

3.7.4.4.5.2 Proposed Kayenta Mine Complex

Cumulative effects at the KMC could result from mine-related N-Aquifer pumping combined with projected community pumping. In addition, concerns have been expressed that retention of surface water at the proposed KMC could reduce water availability for other uses at distances far downstream of the coal leasehold. Such uses could involve agriculture along Moenkopi Wash, retention for livestock watering downstream on Dinnebito Wash, or others.

Cumulative Effects on N-Aquifer Water Levels and Groundwater Quality

Because combined N-Aquifer pumping rates under this Renewable PFR Alternative would be the same as those for the Proposed Action, potential cumulative impacts would be the same. Minor to moderate effects on N-Aquifer water levels would occur, and negligible impacts to N-Aquifer water quality would occur.

Effects of Combined Community- and Mine-related Pumping on N-Aquifer Springs, Seeps, and Stream Baseflows

Because combined N-Aquifer pumping rates under this alternative would be the same as those for the Proposed Action, potential cumulative impacts would be the same as for the Proposed Action and the Natural Gas PFR. Minor to moderate drawdown would occur in the N-Aquifer wells. Discharges at some N-Aquifer springs would be reduced by minor amounts, whereas none to negligible effects would occur at others. Cumulative declines in N-Aquifer contributions to stream baseflows would be negligible to major, depending on the stream location.

Effects of Mining Activities on Surface Water Flows for Cumulative Downstream Uses

Because surface water flows from the leasehold have no or negligible effect on channel flows at USGS gages further downstream on Moenkopi Wash or Dinnebito Wash, there would be no effects on distant cumulative downstream uses under this Renewable Alternative.

3.7.4.4.5.3 Transmission Systems and Communication Sites

No cumulative impacts to water resources would occur, assuming that transmission line operations and maintenance would comply with regulatory permit requirements and applicable agency ROW stipulations related to water resource features.

3.7.4.5 Tribal Partial Federal Replacement Alternative

Under the Tribal PFR Alternative, between 100 MW and 250 MW of power generation from the NGS would be replaced by power supplied by a new photovoltaic generation facility on tribal land, displacing an equivalent amount of power from the federal share of NGS generation. The construction of a new photovoltaic generation site on tribal land would result in between 1,200 and 3,000 acres of new surface disturbance. The Tribal PFR facility would be analyzed in a separate NEPA process once a facility location is identified.

This discussion is divided into two parts. The first part describes assumptions about the alternative photovoltaic supply site and operational characteristics. Water resources impacts that could occur would be addressed in subsequent NEPA actions. The second part addresses the impacts to water resources from reducing the power generated at NGS with consequent reductions in coal production at the Kayenta Mine.

The following list presents key assumptions about water resources related to a new photovoltaic generation site on tribal land. Based on these characteristics, future water resources impacts at such a site would be none to negligible. The following water management-related aspects of such a facility are assumed as noted below.

- A photovoltaic power site would typically be located on a dry, upland site. New surface disturbance would be required over time, and would be conducted in compliance with applicable regulatory requirements and agency stipulations.
- Transmission lines from the facility would be constructed in accordance with applicable agency ROW permit stipulations and construction storm water permit requirements (including a Storm Water Pollution Prevention Plan), federal floodplain requirements (Executive Order 11988/13690), and hydraulic considerations for channel scour and bank migration at stream crossings.
- An SPCC Plan would be implemented and maintained to prevent, or respond to and report, spills or leaks of petroleum products. Operations and maintenance activities would be conducted in compliance with a current industrial NPDES permit, with attendant Storm Water Pollution Prevention Plan.
- All water used for potable or sanitary uses and for other operational uses (e.g., solar panel washing and maintenance, dust suppression at the plant site and access roads, etc.) would be obtained through existing water rights. Any depletions would be approved and mitigated if necessary through applicable agency requirements and approvals.
- Only non-hazardous materials would be disposed of in landfills on the site.

- The tribal photovoltaic energy source that generates power would not result in deposition to surface water of the trace elements associated with coal combustion under the Proposed Action. This difference in emissions is addressed in Section 3.1.

Impact issues for this PFR alternative are discussed across the range of NGS unit operations (3-Unit and 2-Unit) and associated alternative power reductions (100 MW and 250 MW) from the least NGS power reduction to the greatest. Reductions in NGS power generation would proportionally reduce the quantity of coal delivered from the Kayenta Mine. The focus of this discussion is to distinguish differences in impacts within the operational range of the alternative to provide a basis for comparison with the Proposed Action.

3.7.4.5.1 Navajo Generating Station

The following topics discuss potential impacts to water resources if 100 MW to 250 MWs of power generation were replaced at NGS. Under this alternative, alternative power would be purchased from a new photovoltaic source of electrical power generation on tribal land.

3.7.4.5.1.1 Impacts to Surface Water or Groundwater Quantity or Quality from Dry Ash Disposal

Potential impact considerations would be similar to those described for the Natural Gas PFR. Because of these factors, no impacts to water resources at the dry ash disposal area would occur.

3.7.4.5.1.2 Impacts to Surface Water or Groundwater from Spills or Leaks at Fluid Storage or Evaporation Ponds

Potential impact considerations would be similar to those described for the Natural Gas PFR. No water resources impacts would occur. Similar to the Proposed Action and the Natural Gas PFR, water management under this alternative would include practices and procedures described in the Groundwater Protection Plan. These would include continued implementation of the Perched Water Dewatering Plan (**Appendix 1B**). Because of ongoing recovery and discharge of leaks to the plant process water stream, no impacts to the N-Aquifer would occur under this alternative.

3.7.4.5.1.3 Effects of Water Withdrawals for NGS on Water Levels and Surface Area of Lake Powell

Potential impact considerations would be similar to those described for the Natural Gas PFR. Negligible water resources impacts would occur.

3.7.4.5.1.4 Effects of Airborne Deposition of Trace Elements on Water Quality within a 20-km Radius of the Station

Potential impact considerations would be similar to those described for the Natural Gas PFR. Negligible water resources impacts would occur.

3.7.4.5.2 Proposed Kayenta Mine Complex

Under the Tribal PFR, it is assumed that all proposed coal areas will be mined, but at a lower rate and on a modified schedule compared to the Proposed Action. For the 3-Unit Operation, coal production is estimated to range between 7.701 million tpy to 7.941 million tpy, compared to 8.100 million tpy for the Proposed Action 3-Unit Operation. For the 2-Unit Operation, coal production is estimated to range between 5.101 million tpy to 5.341 million tpy, compared to 5.500 million tpy for the Proposed Action 2-Unit Operation. The extent of mine-related surface disturbance could be modified by proportional changes from the Proposed Action, as estimated in **Table 3.7-40**.

Table 3.7-40 Proposed KMC Surface Disturbance Estimates, Proposed Action Compared to the Tribal PFR Alternative

NGS Operation	Proposed Action Disturbance (acres)	Tribal PFR, 100-MW Disturbance (acres)	Tribal PFR, 250-MW Disturbance (acres)
NGS 3-Unit	5,230	5,124	4,968
NGS 2-Unit	4,741	4,599	4,409

3.7.4.5.2.1 Effects of Mine-related Pumping on N-Aquifer Groundwater Levels and Quality

Potential impact considerations would be similar to those described for the Natural Gas PFR. Because of this, the Tribal PFR would generate minor mine-related effects on N-Aquifer water levels and negligible effects on groundwater quality.

3.7.4.5.2.2 Effects of Mine-related N-Aquifer Pumping on Springs, Seeps, and Stream Baseflows

Mine-related rates of groundwater withdrawals from the N-Aquifer are assumed not to change. Because of this, the Tribal PFR would generate none to negligible mine-related effects on springs, seeps and stream baseflows associated with N-Aquifer sources.

3.7.4.5.2.3 Effects of Mining Activities on Groundwater Levels and Water Quality in the Wepo Formation, Alluvial Aquifers, and Related Shallow Springs and Seeps

Groundwater levels and water quality in these shallower aquifers would be affected by variations in natural background conditions. Negligible impacts to water levels would result. Water quality effects would be slightly less than described for a comparable Proposed Action operation, due to the decrease in new mining disturbance under a Tribal PFR. Localized minor water quality impacts would result. Ongoing availability of supplies from PWCC ponds and impoundments would continue to support these livestock and wildlife uses in and near the leasehold.

3.7.4.5.2.4 Effects of Mining Activities on Surface Water Flows and Water Quality in Streams and Ponds

New mining disturbance would be somewhat less than in a comparable Proposed Action operation, as depicted in **Table 3.7-40** above. Impact considerations would be the same as those described for the Natural Gas PFR. Due to downstream lateral inflows and high background rates of evapotranspiration and channel seepage, effects downstream of the leasehold would be none to negligible. Surface water quality would be maintained by continuing mine water management programs, with none to negligible impacts. Existing water uses (habitat and livestock watering) would not be affected, due to ongoing availability of supplies from PWCC ponds and impoundments.

3.7.4.5.3 Transmission Systems and Communication Sites

Operation of the WTS and STS would continue for the life of the project. The timing of decommissioning and final reclamation requirements for the WTS and STS ROWs ultimately would be determined by the authorities with responsibility for ROW issuance.

Additional disturbance could occur to an unknown number of acres related to connecting a new photovoltaic generation site on tribal land to the existing transmission system and would be evaluated in a subsequent NEPA action. Assuming that appropriate tribal and federal ROW permit approvals and agreements would be obtained or maintained, and that those would entail provisions and stipulations protective of water resources (see discussions under "Regulatory Framework" and the Proposed Action), then no transmission system impacts to water resources would occur under this alternative.

3.7.4.5.4 Project Impact Summary – All Project Components

Based on the assumptions for this alternative, there would be slightly less effects on Lake Powell water levels and extent that under a Proposed Action operation. There would be none to negligible differences between the Tribal PFR and the Natural Gas PFR. The overall impacts to lake extent and water level would be negligible. Differences from a respective Proposed Action operation would be negligible. Somewhat less trace element deposition (for arsenic, mercury, and selenium) from NGS emissions would occur, relative to a comparable power generation rate from a Proposed Action operation. This would reduce the potential NGS impacts to surface water quality from a Tribal PFR to negligible levels.

Mine-related N-Aquifer impacts at the Proposed KMC would be the same as those from the Proposed Action. Impacts to groundwater levels and quality in shallow aquifers on the leasehold would be the same or slightly less than in a comparable Proposed Action, due to a reduction in new mining disturbance and the potential for corresponding changes in mine configurations. Similarly, potential surface water impacts would be the same or slightly less than a comparable Proposed Action operation. Existing water uses for livestock and habitat would be maintained the same as under the Proposed Action, due to continuing access to PWCC ponds and impoundments.

3.7.4.5.5 Cumulative Impacts

3.7.4.5.5.1 Navajo Generating Station

<u>Effects of Cumulative Water Withdrawals on Water Level and Surface Area of Lake Powell</u>

Potential cumulative withdrawal effects would be very similar to those tabulated for the Natural Gas PFR. Cumulative withdrawals would have a more substantial effect on the water level and surface area of Lake Powell than NGS withdrawals alone. These would be negligible to minor impacts. Differences between the estimated cumulative Tribal PFR changes and those of a comparable cumulative Proposed Action operation are negligible.

<u>Effects of Cumulative Airborne Deposition of Trace Elements on Water Quality within the Overall Surface Water Study Area</u>

The very small contributions of selected trace elements (arsenic, mercury, selenium) predicted for the Proposed Action would be reduced in NGS emissions from this alternative. Other cumulative contributions would not change, so impacts to surface water quality in the Colorado River, Lake Powell, and the San Juan River would be very similar to cumulative impacts described for a corresponding Proposed Action operation. Negligible water quality impacts would occur in Lake Powell and along the upstream and downstream sections of the Colorado River. Minor to moderate water quality impacts would occur along the San Juan River.

<u>Past and Present Effects of Water Management at NGS on N-Aquifer Groundwater Quality</u>

As described previously in the Affected Environment discussion, a zone of perched water occurs at shallow depths below the NGS plant area. This water results from small leaks at plant components such in the cooling tower area, from previously unlined ponds, and some drainage ditches. A perched water recovery, monitoring, and reporting program was previously established and implemented in coordination with the USEPA to address conditions at the plant. This would be a continuing activity under the Tribal PFR Alternative. No past or present impacts to N-Aquifer water quality have occurred.

3.7.4.5.5.2 Proposed Kayenta Mine Complex

Cumulative effects at the KMC could result from mine-related N-Aquifer pumping combined with projected community pumping. In addition, concerns have been expressed that retention of surface water at the proposed KMC could reduce water availability for other uses at distances far downstream of the coal leasehold. Such uses could involve agriculture along Moenkopi Wash, retention for livestock watering downstream on Dinnebito Wash, or others.

<u>Cumulative Effects on N-Aquifer Water Levels and Groundwater Quality</u>

Because combined N-Aquifer pumping rates under this Tribal PFR Alternative would be the same as those for the Proposed Action, potential cumulative impacts would be the same. Minor to moderate effects on N-Aquifer water levels would occur, and negligible impacts to N-Aquifer water quality would occur.

<u>Effects of Combined Community and Mine-related Pumping on N-Aquifer Springs, Seeps, and Stream Baseflows</u>

Because combined N-Aquifer pumping rates under this Tribal Alternative would be the same as those for the Proposed Action, potential cumulative impacts would be the same as for the Proposed Action and the Natural Gas PFR. Minor to moderate drawdown would occur in the N-Aquifer wells. Discharges at some N-Aquifer springs would be reduced by minor amounts, whereas none to negligible effects would occur at others. Cumulative declines in N-Aquifer contributions to stream baseflows would be negligible to major, depending on the stream location.

<u>Effects of Mining Activities on Surface Water Flows for Cumulative Downstream Uses</u>

Because surface water flows from the leasehold have none to negligible effect on channel flows at USGS gages further downstream on Moenkopi Wash or Dinnebito Wash, there would be no effects on distant cumulative downstream uses under this Tribal Alternative.

3.7.4.5.5.3 Transmission Systems and Communication Sites

No cumulative impacts to water resources would occur, assuming that transmission line operations and maintenance would comply with regulatory permit requirements and applicable agency ROW stipulations related to water resource features.

3.7.4.6 No Action

Water resources topics addressed for the No Action Alternative remain in the general categories as those listed for the Proposed Action, but obviously the potential impacts would differ. Surface water quantity and quality, groundwater quantity and quality, and effects on existing water uses are the major topics of interest for the No Action Alternative, at both NGS and KMC.

3.7.4.6.1 Navajo Generating Station

3.7.4.6.1.1 Ash Disposal Area, Existing Ponds, and Other Components

As described in Chapter 1.0 for the No Action Alternative, some decommissioning activities would be initiated at the NGS in 2018, with effective shutdown of the plant occurring by the end of 2019. Ponds, landfills, industrial fluids and wastes, and other water-related components or materials would be addressed by SRP and other NGS participants through further site-specific closure planning and implementation. Decommissioning of other plant components and the transmission systems is described in the respectively titled section of **Appendix 1B**. A Professional Engineer would develop an industry-recognized and generally accepted good engineering practices closure plan (Groundwater Protection Plan). **Appendix 1B** provides further detail. USEPA regulations at time of closure and lease requirements would be used as the basis for plant decommissioning and environmental demolition requirements. The Groundwater Protection Plan would be the guidance document for water-related decommissioning work, with additional specific component plans, implementation, and monitoring conducted by SRP with appropriate agency coordination. This plan would include, but not be limited to:

- Investigating soil or material constituents in or adjacent to ponds and landfills, and compare them to appropriate screening levels;
- Recovering remaining perched water underlying the plant site and ash disposal area;
- Removing, decontaminating, or burying soils and other materials in place according to applicable federal requirements;
- Stabilizing remaining wastes and waste residues as necessary to support final cover, and installing final cover per the design requirements;
- Eliminating (e.g., through evaporation or other means) or solidifying free liquids and other residues, then stabilizing and covering the sites according to the design requirements;
- Controlling erosion and runoff;
- Monitoring and maintaining post-closure conditions related to cover integrity, runoff and erosion controls, and groundwater conditions. The types and durations of monitoring and maintenance activities would be pursuant to USEPA regulations at time of closure, including the CCR regulations, other applicable federal regulations, and lease requirements.
- Conducting closure and post-closure monitoring in accordance with the Groundwater Protection Plan and agency interactions.

Management of fluids and wastes would continue as the decommissioning process proceeds to minimize impacts to surface water resources during closure activities. Ongoing storm water management practices would continue to control erosion, runoff, and off-site movement of fluids or wastes. By continuing storm water management practices and implementing a coordinated closure design, long-term impacts to surface water resources at NGS would be avoided or reduced. Short-term impacts to surface water or groundwater quality could occur during decommissioning activities, due to inadvertent spills, leaks, storm damage, or runoff bypasses. If they occur, such events would be promptly mitigated through countermeasures.

Impacts to groundwater (N-Aquifer) resources would be avoided or reduced to unobservable levels during and after plant decommissioning. This would occur by continuing to implement the Groundwater Protection Plan and its accompanying Perched Water Dewatering Work Plan (**Appendix 1B**). Groundwater monitoring (and any recovery or remediation activities, if necessary) would continue according to commitments and agency coordination. With these procedures and practices, long-term, post-closure water resources impacts from the No Action Alternative would be avoided or mitigated.

Because of these practices, the No Action Alternative would create no future impacts to water resources from components within the NGS plant site.

3.7.4.6.1.2 Lake Powell

Under the No Action Alternative, NGS water supply withdrawals from Lake Powell would cease. The allocated consumptive water volume is 34,100 acre-feet per year. This volume would remain under the administration of the State of Arizona through its Colorado River water rights. The actual present and planned withdrawal volume at NGS is about 29,000 acre-feet per year. That amount could help meet other water demands. It represents about 0.11 percent of total reservoir water capacity at a pool elevation 3,700 feet, based on recent information (Reclamation 2007). If the water remained in storage at approximately that elevation, the existing reservoir surface area would increase by about 132 acres, to a total of about 160,782 acres. It is unknown what uses might be made of the water currently allocated to NGS. Water could be delivered elsewhere in Arizona to beneficial uses supported by Lake Powell and in the Upper Colorado River Basin.

Airborne deposition of arsenic, mercury, and selenium from NGS would cease within the 20-km radius near-field study area, and NGS would not contribute to cumulative regional rates of deposition in the outlying surface water study areas.

3.7.4.6.2 Proposed Kayenta Mine Complex

As described for No Action in Chapter 2.0, PWCC has indicated it would cease mining operations at the Kayenta Mine in 2019, and proceed to final reclamation of the Kayenta Mine, the former Black Mesa Mine, and all support facilities not otherwise approved as permanent facilities. Mine closure and reclamation would take place according to applicable permit documentation and provisions.

3.7.4.6.2.1 N-Aquifer Water Levels, Groundwater Quality, and Uses

Under the No Action, N-Aquifer pumping would decline in 2019 from its current withdrawal rate of about 1,200 to 1,400 acre-feet per year. Pumping would continue for reclamation operations, local water supplies, the Many Mules Navajo Nation water supply project, and dust suppression. These would require less water under the No Action than mining operations would during an action alternative. During the period 2020 through 2022, N-Aquifer pumping would decline to about 500 acre-feet per year. Subsequent rates would be approximately 100 acre-feet per year during reclamation. Reclamation activities would be completed in approximately 2033. This would be a similar reduction in N-Aquifer pumping as would occur in a Proposed Action option, but it would occur about 25 years sooner. About 100 acre-feet per year would be pumped from the PWCC wells mainly for domestic supplies after 2033.

Gradual increases to meet local domestic use demands for N-Aquifer water would continue under No Action after the Year 2033. Projected community water supply pumping from the N-Aquifer would continue into the future.

Under the No Action Alternative mining at the KMC ceases at the end of 2019. PWCC pumping would be reduced from 1,200 acre-feet per year at the end of 2019 to 500 acre-feet per year from 2020 through 2023 (3 years) then to 100 acre-feet per year from 2024 through 2033 (10 years). As noted previously, while mine pumping would be reduced and eventually cease completely, the cone of depression would continue to spread for many years. During the No Action Alternative, N-Aquifer water levels in the PWCC leasehold would start to recover within a year, and in nearby wells within a few years. However, as a result of recent mine-related pumping, water levels in some distant N-Aquifer wells will continue to fall for a period of time.

To assess the impact of the No Action Alternative on N-Aquifer water levels, data for the year 2057 were extracted from the groundwater flow model output. This year was selected as it is the year in which all mine pumping ceases in the proposed alternative and is within the reasonably foreseeable future in terms of population and water use projections. The groundwater flow model uses population and water use projections developed by the EIS team with input from the tribes and cooperating agencies. The model was run with community, windmill and PWCC pumping, and also with only community and windmill pumping; the difference of these two runs provides the water level change (drawdown) due to PWCC pumping (**Appendix WR-9**). It should be noted that both runs include the effects of past PWCC pumping on water levels prior to 2019.

Water level change (drawdown) from 2019 through 2057 due to community (including windmill) pumping and PWCC pumping was extracted from the model, and the relative percent of each on water level change in 2057 computed, as presented in **Table 3.7-41**. **Table 3.7-41** shows that the effects of mine pumping would continue (i.e., drawdown in most wells is still occurring in 2057, 25 year after PWCC pumping ceases) under the No Action Alternative, even though all mine-related pumping would have ceased. The table also shows that by 2057 water level change in most locations would be dominated by increasing community pumping.

Table 3.7-41 N-Aquifer Water Level Change from 2019 to 2057, Community and PWCC Effects, No Action Alternative

Community	Community (feet)	PWCC (feet)	Community / PWCC (percent)
Navajo			
Kayenta	147.04	3.18	98 / 2
Shonto	30.13	0.01	100 / 0
Dennehotso	32.48	0	100 / 0
Chilchinbito	102.47	13.75	88 / 12
Rough Rock	50.44	2.47	95 / 5
Forest Lake[1]	-16.38	-22.72	42 / 58
Pinon	62.71	14.73	81 / 19
Hard Rock	70.15	14	83 / 17
Shonto Junction	1.17	0.01	99 / 1
Red Lake	12.58	0.01	100 / 0
Rocky Ridge	52.23	11.09	82 / 18
Tuba City	58.17	0	100 / 0
Hopi			
Moenkopi	161.98	0.01	100 / 0
Hotevilla	39.93	2.69	94 / 6
Bacavi	31.62	2.51	93 / 7
Low Mountain	167.57	12.08	93 / 7
Kykostmovi	25.45	2.44	91 / 9
Hopi Civic Center	16.12	2.77	85 / 15
Shungopavi	10.24	1.99	84 / 16
HAMP[2]	172.17	10.99	94 / 6

[1] The water level at Forest Lake is still recovering from 2005 cessation of past higher PWCC pumping for Black Mesa coal slurry pipeline. This rise masks any drawdown that is continuing after PWCC pumping has ceased.

[2] Wells are placed at Hopi High School, Hopi Cultural Center, Shipaulovi, Second Mesa Day School, Keams Canyon and Polacca.

HAMP = Hopi Arsenic Mitigation Project.

Table 3.7-42 gives the projected depth to water in 2057 and shows that the effect of mine pumping on N-Aquifer depths to water would continue under the No Action Alternative, even though all mine pumping would have ceased. The table also shows that by 2057 the residual effect of PWCC pumping on the lift required to get water to the surface in key community production wells would be less than 2 percent of the total lift.

Table 3.7-42 No Action Alternative, 2019-2057 Percent Increase in N-Aquifer Lift at Key Community Production Wells due to PWCC Pumping

Community	Depth to Water (feet bgs)	PWCC Drawdown (feet)	Community / PWCC (percent)
Navajo			
Kayenta	568	3.18	99 / 1
Shonto	393	0.01	100 / 0
Dennehotso	47	0.0	100 / 0
Chilchinbito	638	13.75	98 / 2
Rough Rock	718	2.47	98 / 2
Forest Lake[1]	1,121	-22.72	98 / 2
Pinon	900	14.73	98 / 2
Hard Rock	789	14.0	98 / 2
Shonto Junction	7	0.01	100/ 0
Red Lake	200	0.01	100 / 0
Rocky Ridge	602	11.09	98 / 2
Tuba City	190	0.0	98 / 2
Hopi			
Moenkopi	562	0.0	100 / 0
Hotevilla	1,011	0.3	100 / 0
Bacavi	1,025	0.3	100 / 0
Low Mountain	834	1.8	99 / 1
Kykostmovi	281	1.0	99 / 1
Hopi Civic Center	440	0.7	99 / 1
Shungopovi	963	0.2	100 / 0
HAMP[2]	601	2.6	98 / 2

[1] Water level at Forest Lake is still recovering from 2005 cessation of past higher PWCC pumping for Black Mesa coal slurry pipeline.

[2] Wells are placed at Hopi High School, Hopi Cultural Center, Shipaulovi, Second Mesa Day School, Keams Canyon and Polacca.

HAMP = Hopi Arsenic Mitigation Project.

Impacts to springs would be the less than those identified as direct effects for the Proposed Action (**Table 3.7-20**) and more similar to those described for cumulative impacts considered under the Proposed Action. Predicted effects of the No Action Alternative on stream baseflows are indicated in **Table 3.7-31** as presented for the cumulative impact assessment under the Proposed Action. Predictions for the No Action in the Year 2110 indicate that community pumping then would decrease baseflows by zero to 0.145 cfs in the channels listed. The major baseflow declines due to No Action pumping effects from 2019 to 2110 would be at Chinle Creek (46.8 percent), Laguna Creek (42.2 percent), Polacca Wash (31.4 percent), and Begashibito Wash (18.3 percent). Locations where these effects were simulated are indicated on **Figures 3.7-3** and **3.7-12**.

3.7.4.6.2.2 Wepo Aquifer and Alluvial Groundwater Levels, Quality, and Uses

Both the alluvial aquifer and the Wepo aquifer are strongly influenced by climate and local recharge conditions. This would continue under the No Action Alternative. Alluvial groundwater levels and water quality would vary, and remain similar to the conditions described in the Affected Environment and **Appendix WR-3**. No other effects on alluvial groundwater levels or quality would result from the No Action. Similarly, Wepo Formation groundwater levels and water quality would remain similar to those described in the Affected Environment and **Appendix WR-5**. With reduced mining disturbance from the No Action Alternative, local drawdown in the Wepo Formation near mine pits would be reduced or avoided. In comparison to a Proposed Action option, this would reduce the potential for negligible to minor related impacts to springs and stream baseflows near the N-9, N-10, N-11 Extension, J-19, and J-21/J-21W coal resource areas. Similar to the Proposed Action and others alternatives. Anticipated impacts to the limited existing Wepo or alluvial water uses in or near the leasehold would be negligible under the No Action Alternative. Under the No Action, there would be less potential to disturb the various water features (springs, stream baseflows) in and near the areas that would be mined under a Proposed Action option. Comparing the direct effects of the No Action to the Proposed Action, the net difference between water availability and quality for existing uses is negligible.

3.7.4.6.2.3 Shallow Aquifer Springflows and Water Quality

Flows and water quality at shallow-aquifer springs would remain similar to those reported in **Appendix WR-4**. Conditions at springs with shallow-aquifer sources (the alluvium or Wepo Formation) would continue to reflect overall climatic trends and influences from local recharge and geologic conditions.

In the J-19 area, the removal of NSPG191 would not occur under the No Action. Comparing the Proposed Action to a No Action that would maintain NSPG191, there would be a small net difference between water availability and quality for existing uses in the J-19/J-21/J-21W area. NSPG191 has a monitored range of flows from 0.0 to 4.0 gpm, but typically it does not flow. When flowing, its average measured rate is 0.55 gpm. Permanent ponds or impoundments J21-C (2007); J21-RB (1980); J21-I (2012); J7-JR (2001); and J16-L (2007) already have been constructed and maintained by PWCC as alternative water supplies in the J-19/J-21/J-21W area. In light of these permanent features, maintaining spring NSPG191 would provide negligible benefits to existing livestock and wildlife water uses under the No Action Alternative.

3.7.4.6.2.4 Surface Water Flows, Water Quality, and Uses

As with previous phases of mine operations and reclamation, surface runoff at the proposed KMC would be managed through ponds, impoundments, ditches, and diversions. The effects of these structures on runoff water quantity were previously characterized as of Year 2019 for the Proposed Action (**Table 3.7-17**). From those projections, approximately 25 to 30 percent of runoff from the leasehold would be retained by water management practices. After reclamation, there would be approximately a seven percent reduction in the amount of runoff retained, generally paralleling the total indicated in **Table 3.7-25**.

Under the No Action Alternative, new mining at coal resource areas N-10 and N-11 Extension would not occur. Expanded mining at the N-9, J-19, J-21, and J-21W areas would not occur after Year 2018, since decommissioning at the NGS would be beginning. As a result, runoff quantities from these expansion areas and their upgradient watersheds would not be retained within the leasehold. Under the No Action Alternative, a projected 20 to 25 percent increase in retained runoff from post-2019 mining under the Proposed Action would not occur. Due to permanent post-mining impoundments, which provide livestock and habitat uses within the leasehold, approximately 20 percent of runoff would be retained after reclamation. This would be the same as that projected for the Proposed Action options, and would be a minor impact, entailing a hydrologic shift from shorter-term ephemeral or limited intermittent streamflows, to longer duration impounded water. Under the No Action Alternative, reclamation of these remaining temporary ponds would be accelerated. Permanent impoundments would remain to provide water used by livestock and wildlife.

Runoff water quality under the No Action Alternative be similar to that reflected in the tables presented in **Appendix WR-1**. In general, most water quality constituents would remain at concentrations within designated use standards. Sulfate and TDS concentrations would vary but generally would remain elevated, as they often are in background water quality. Total aluminum and lead concentrations would occasionally be elevated. These chemical conditions would parallel the water quality from undisturbed inflows and springs as documented outside the effects of mining. Since there would be less surface disturbance and a somewhat shorter reclamation time-frame at the proposed KMC, sediment yields from disturbed areas would be reduced more quickly under the No Action Alternative. This would create negligible effects, since sediment yields are well-controlled currently at the proposed KMC, and also would be under any action alternative.

3.7.4.6.3 Transmission Systems and Communication Sites

The NGS transmission system is an established part of the western U.S. transmission grid and supports reliability and delivery of power throughout the region, well beyond the power generated by the NGS. Therefore, under the No Action Alternative it is likely that that one, several, or all of the land owners/managers of the transmission line rights-of-way and communication site leases would renew some portion of the facilities to keep the power grid performing as expected.

In the event it is determined that some or all of the transmission systems and communication site ROWs are not renewed, a lengthy study and permitting process would need to occur before any decommissioning is initiated due to the essential and integral nature of these facilities with the western electric grid. As noted in Section 2.3.3, up to 4,826 acres within and alongside the transmission system corridors could be temporarily disturbed if the entirety of the transmission systems and communication sites were decommissioned and removed.

By conducting activities within appropriate guidelines and complying with permit approvals and conditions, impacts to water resources would be none to negligible. If decommissioning of the existing NGS transmission systems is required, it would follow the decommissioning approach as set forth in **Appendix 1B**. Resulting water resources impacts would be none to negligible.

3.7.4.6.4 No Action Impact Summary – All Project Components

For the NGS, the impact assessment for the No Action focuses on the potential for:

- Impacts to the N-Aquifer from plant and facilities decommissioning and reclamation;
- Effects of other water supply withdrawals on Lake Powell; and
- Surface water quality impacts from airborne deposition of selected trace elements in Lake Powell and the Colorado River from other regional power plants.

Potential water resources impacts at the NGS would be avoided or mitigated by site-specific closure planning and engineered practices that would close and reclaim ponds, landfills, industrial fluids and wastes, and other water-related components or materials. Closure planning and activities would be coordinated appropriately with the USEPA and Navajo Nation. Storm water management and the Groundwater Protection Plan (with its accompanying Perched Water Dewatering Work Plan) would continue to be implemented during plant closure and reclamation. The No Action Alternative would create no impacts to water resources from components within the NGS site.

NGS water supply withdrawals from Lake Powell would cease. This represents a negligible amount: about 0.11 percent of total reservoir water capacity. That water would remain under the administration of the State of Arizona. Scheduled releases and other withdrawals, such as the proposed Lake Powell Pipeline (if approved and completed), would continue to affect reservoir volume and extent.

NGS would not contribute to regional rates of airborne deposition of arsenic, mercury, or selenium in the outlying surface water study areas. This would be a negligible effect. Other coal-fired power plants in the region would continue to contribute these trace elements to surface waters in the study area. Generally these would be negligible effects, but water quality concerns would remain for the lower San Juan and Colorado rivers due to salinity and other constituents.

At the proposed KMC, the impact assessment for the No Action focuses on the potential for:

- Community pumping impacts to N-Aquifer groundwater levels and water quality;
- Reduced discharges in N-Aquifer springs and supported stream baseflows;
- Reduced groundwater levels and water quality in the shallower Wepo and alluvial aquifer zones in the leasehold after reclamation;
- Reduced flow rates, occurrence, or water quality at shallow springs and seeps, and corresponding effects on existing water uses in and near the coal leasehold after reclamation;
- Reduced flows or water quality in stream channels and corresponding effects on existing water uses in and near the coal leasehold after reclamation; and
- Additional retention of surface runoff in ponds and impoundments, and the suitability of retained water quality to support water uses in the mine-area locale after reclamation.

In the No Action case, existing mine-related N-Aquifer pumping would decline to about 500 acre-feet per year during the period 2020 through 2022. After that, pumping would continue for reclamation operations, local water supplies, the Many Mules project, and dust suppression. Rates would be approximately 100 acre-feet per year during reclamation until approximately 2033. Unrelated to mining use, gradual increases to meet local domestic use demands and other PWCC commitments for N-Aquifer water would continue under No Action after the Year 2033. These would be non-mining uses.

Community pumping from the N-Aquifer is projected to increase in the future, from 3,037 acre-feet per year in 2011 to approximately 17,595 acre-feet annually in 2110. In the No Action case, projected community pumping by the year 2057 would create the vast majority of estimated water level declines in N-Aquifer wells. Approximately 147 feet of community drawdown would occur at Kayenta, 162 feet of drawdown at the Moenkopi wellfield, 168 feet of drawdown at Low Mountain, and declines in other community wells (**Table 3.7-41**). Instead of mine-related pumping until 2057 under the Propose Action, residual PWCC effects in that year from the No Action case would range from about 14.7 feet of drawdown at Pinon to about 22.7 feet of recovery at Forest Lake. Approximately 3.2 feet of residual PWCC drawdown would occur at Kayenta, 0.01 feet at the Moenkopi wellfield, and 12.1 feet of drawdown at Low Mountain (**Table 3.7-41**). These would be negligible effects. In 2057, the increase in pumping lift (the vertical distance water would have to be pumped to the surface) due to residual PWCC effects would range from zero to 2.6 percent. These would be none to negligible effects.

With the No Action Alternative, baseflow declines in streams would largely result from projected community pumping. The most noticeable effects would be at Chinle Creek, Laguna Creek, and Polacca Wash (see **Table 3.7-17**). These would be major impacts. Simulated reductions in flow at both monitored and non-monitored springs also are predicted to result from increases in community pumping over time. Some effects would be substantial. Future effects on those flow reductions from the No Action Alternative at the proposed KMC would be negligible.

Assuming that new transmission lines would be constructed in approved ROWs, such activities would need to comply with applicable permit requirements and other agency policies and stipulations. If needed, decommissioning of the existing transmission system would proceed according to agency requirements and agreements. By doing so, impacts to water resources would be none to negligible under the No Action Alternative.

3.7.5 References

Arizona Department of Environmental Quality. 2016. Article 1. Water Quality Standards for Surface Waters. Title 18, Environmental Quality, Chapter II, Department of Environmental Quality. Effective January 31, 2009. ADEQ Water Quality Division, Phoenix, Arizona. Internet website: http://legacy.azdeq.gov/environ/water/standards/. Accessed July 16, 2016.

Arizona Department of Water Resources (ADWR). 2010a. Arizona Water Atlas, Volume 2, Section 2.1.3. Climate of the Little Colorado Basin. Phoenix, Arizona. Internet website: http://www.azwater.gov/AzDWR/StatewidePlanning/WaterAtlas/. Accessed December 15, 2014.

Arizona Department of Water Resources (ADWR). 2010b. Arizona Water Atlas, Volume 2, Eastern Plateau Planning Area. Phoenix, Arizona. Internet website: http://www.azwater.gov/AzDWR/StatewidePlanning/WaterAtlas/. Accessed December 15, 2014.

Arizona Department of Water Resources (ADWR). 2008. Preliminary Hydrographic Survey Report for the Hopi Indian Reservation. In: Re the General Adjudication of the Little Colorado River System and Source. December 2008. Internet website: http://www.azwater.gov/AzDWR/Hydrology/Library/HydrologicSurveyReports.htm. Accessed May 13, 2016.

Arizona Department of Water Resources (ADWR). 1989. Hydrology of the Little Colorado River System. Special Report to the Settlement Committee. In: Re the General Adjudication of the Little Colorado River System and Source. October1989. Internet website: http://www.azwater.gov/AzDWR/SurfaceWater/Adjudications/GilaRiverandLittleColoradoRiverGeneralStreamAdjudications.htm. Accessed May 13, 2016.

Bureau of Land Management (BLM). 2009a. Standard Form SF 299. Application for Transportation and Utility Systems and Facilities on Federal Lands. Internet website: http://www.gsa.gov/portal/forms/download/117318. Accessed July 14, 2016.

Bureau of Land Management (BLM). 2009b. Obtaining a Right-of-Way on Public Lands. Bureau of Land Management Lands and Realty Program. Internet website: http://www.blm.gov/style/medialib/blm/wo/MINERALS__REALTY__AND_RESOURCE_PROTECTION_/cost_recovery.Par.58417.File.dat/ObtainingaROWPamphlet.pdf. Accessed July 14, 2016.

Carr, D. A. 1991. Facies and Depositional Environments of the Coal-Bearing Upper Carbonaceous Member of the Wepo Formation (Upper Cretaceous), Northeastern Black Mesa, Arizona. In: J. D. Nations and J. G. Eaton, editors. Stratigraphy, Depositional Environments, and Sedimentary Tectonics of the Western Margin, Cretaceous Western Interior Seaway. Geological Society of America Special Paper 260. Geological Society of America, Boulder, Colorado.

Cooley, M. E., J. W. Harshbarger, J. P. Akers, and W. F. Hardt. 1969. Regional Hydrogeology of the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah. With a section on Vegetation by O. N. Hicks. Geological Professional Paper 521-A. With 15 plates. Prepared in cooperation with the Bureau of Indian Affairs and the Navajo Tribe. U.S. Government Printing Office, Washington, D.C.

Electric Power Research Institute (EPRI). 2016. A Case Study Assessment of Trace Metal Atmospheric Emissions and Their Aquatic Impacts in the San Juan River Basin. Phase 2: Navajo Generating Station. 3002006244. R. Goldstein and L. Levin. Final Report. April 2016.

Ferrari , R. L. 1988. 1986 Lake Powell Survey. U.S. Department of the Interior, Bureau of Reclamation. Denver Office, December 1988.

Harris, R. C. 2004. Giant Desiccation Cracks in Arizona. Arizona Geology 34:2(Summer 2004). Arizona Geological Survey. Tucson, Arizona.

Hart, R. J., H. E. Taylor, and G. M. Anderson. 2012. Establishment of Sentinel Sampling Sites to Monitor Changes in Water and Sediment Quality and Biota Related to Visitor Use at Lake Powell, Arizona and Utah, 2004-2006, U.S. Geological Survey Open-File Report 2012-1237, 25 p.

HDR Engineering, Inc. 2003. Report of Findings for the Assessment of Western Navajo-Hopi Water Supply Needs, Alternatives, and Impacts. HDR Engineering, Inc. for the U.S. Bureau of Reclamation, July 17, 2003.

Hereford, R. 2007. Climate Variation at Flagstaff, Arizona – 1950 to 2007. U.S. Geological Survey Open-File Report 2007-1410, 17 p.

Hopi Tribe Water Resources Program (HTWRP). 1996. Hopi Tribe Wellhead Protection Manual. September 30, 1996. Hopi Tribe Water Resources Program. Kykotsmovi, Arizona.

John, J. 2016. Personal communication regarding well drilling costs on Black Mesa between J. John, Water Management Branch of Navajo Department of Water Resources, Fort Defiance, Arizona and J. Burrell, AECOM. January 25, 2016.

Karlstrom, T. N. V. 1988. Alluvial Chronology and Hydrologic Change of Black Mesa and Nearby Regions. Pages 45 -91 In: The Anasazi in a Changing Environment. G. J. Gumerman, Editor. ISBN 0 521 34631 2. Cambridge University Press, New York, New York.

Leake, S. A., J. P. Macy, and M. Truini. 2016. Hydrologic Analyses in Support of the Navajo Generating Station – Kayenta Mine Complex Environmental Impact Statement. U.S. Geological Survey Open-File Report 2016-1088, 23 p. Internet website: http://dx.doi.org/10.3133/ofr20161088. Accessed July 30, 2016.

Lindsey, R. 2015. World of Change: Water Levels in Lake Powell. June 12, 2015. EOS Project Science Office, Goddard Space Center, National Aeronautics and Space Administration. Internet website: http://earthobservatory.nasa.gov/Features/WorldOfChange/lake_powell.php. Accessed June 19, 2015.

Littin, G. R. 1992. Results of Ground-water, Surface-water, and Water-quality Monitoring, Black Mesa Area, Northeastern Arizona – 1990-91. U.S. Geological Survey, Water-Resources Investigations Report 92–4045.

Macy, J. P. 2014. Personal communication regarding provisional annual data, Northeastern Arizona community pumping withdrawals between J. P. Macy, USGS and J. Burrell, AECOM. July 22, 2014.

Macy, J. P. and J. A. Unema. 2014. Groundwater, Surface-Water, and Water-Chemistry Data, Black Mesa Area, Northeastern Arizona – 2011-2012. U. S. Geological Survey Open-File Report 2013-1304, 42 p. Internet website: http://dx.doi.org/10.3133/ofr20131304. Accessed May 13, 2016.

Macy, J. P. and M. Truini. 2016. Groundwater, Surface-Water, and Water-Chemistry Data, Black Mesa Area, Northeastern Arizona – 2012-2013. U. S. Geological Survey Open-File Report 2015-1221, 43 p. Internet website: http://dx.doi.org/10.3133/ofr20151221. Accessed May 13, 2016

Macy, J. P., C. R. Brown, and J. R. Anderson. 2012. Groundwater, Surface-Water, and Water-Chemistry Data, Black Mesa Area, Northeastern Arizona – 2010-2011. U. S. Geological Survey Open-File Report 2012-1102, 41 p.

National Research Council. 2007. Colorado River Basin Water Management: Evaluating and Adjusting to Hydroclimatic Variability. Committee on the Scientific Bases of Colorado River Basin Water Management. National Research Council, National Academy of Science. ISBN 0-309-10525-0. The National Academies Press, Washington, D.C.

Nations, J. D., R. L. Swift, and H. W. Haven, Jr. 2000. Summary of Cretaceous Stratigraphy and Coal Distribution, Black Mesa Basin, Arizona. Chapter H In: Geologic Assessment of Coal in the Colorado Plateau: Arizona, Colorado, New Mexico, and Utah. U.S. Geological Survey Professional Paper 1625-B. M. A. Kirschbaum, L. N. R. Roberts, and L. R. H. Biewick, editors. Internet website: http://pubs.usgs.gov/pp/p1625b/. Accessed January 27, 2015.

Navajo Nation Environmental Protection Agency (NNEPA). 2010. Navajo Nation Primary Drinking Water Regulations, 1700 – Wellhead Protection Regulations. Navajo Nation Environmental Protection Agency, Public Water Systems Supervision Program. Window Rock, Arizona. Internet websites: http://navajopublicwater.org/NNPDWR2.html , and http://www.navajopublicwater.org/17NNPDWR1700_Wellhead.pdf. Accessed February 16, 2013, and June 30, 2015.

Navajo Nation Environmental Protection Agency (NNEPA). 2008. Navajo Nation Surface Water Quality Standards 2007. May 13, 2008. Prepared by: Navajo Nation Environmental Protection Agency, Water Quality Program. Window Rock, Arizona.

Office of Surface Mining Reclamation and Enforcement (OSMRE). 2012. Review and Analysis of Peabody Western Coal Company's 2011 "Annual Hydrological Data Report, and the USGS's "Ground-water, Surface-Water and Water-Chemistry Data, Black Mesa Area, Northeastern Arizona – 2009-10, and the USGS's "Ground-water, Surface-Water and Water-Chemistry Data, Black Mesa Area, Northeastern Arizona – 2010-11. U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement (Western Region). Denver, Colorado. October 2012.

Office of Surface Mining Reclamation and Enforcement (OSMRE). 2011a. Environmental Assessment: Kayenta Mine Permit (AZ-0001D) Renewal (Navajo County, Arizona). U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement (Western Region). August 2011. 185 pp + appendices.

Office of Surface Mining Reclamation and Enforcement (OSMRE). 2011b. Cumulative Hydrologic Impact Assessment, Peabody Western Coal Company, Kayenta Complex. U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement (Western Region). Denver, Colorado. December 2011.

Office of Surface Mining Reclamation and Enforcement (OSMRE). 2003. Process for Obtaining an NPDES Permit Under Subpart H – Western Alkaline Mine Drainage Category. Memorandum of Understanding between the Office of Surface Mining Reclamation and Enforcement and U.S. Environmental Protection Agency, Region IX. Signed December 19, 2003.

Peabody Western Coal Company (PWCC). 2016. Status and Number of Ponds and Impoundments, 2016, 2019, and LOM. April 14, 2016. Peabody Western Coal Company, Kayenta, Arizona.

Peabody Western Coal Company (PWCC). 2015b. 2014 Annual Hydrology Report. Report to the Office of Surface Mining, Reclamation, and Enforcement, Western Division, Denver, Colorado. April 2015. Peabody Western Coal Company, Kayenta, Arizona.

Peabody Western Coal Company (PWCC). 2014. 2013 Reclamation Status and Monitoring Report for the Black Mesa and Kayenta Mines. Report to the Office of Surface Mining, Reclamation, and Enforcement, Western Division, Denver, Colorado. May 23, 2014. Peabody Western Coal Company, Kayenta, Arizona.

Peabody Western Coal Company (PWCC). 2013. 2012 Reclamation Status and Monitoring Report for the Black Mesa and Kayenta Mines. Report to the Office of Surface Mining, Reclamation, and Enforcement, Western Division, Denver, Colorado. June 6, 2013. Peabody Western Coal Company, Kayenta, Arizona.

Peabody Western Coal Company (PWCC). 2012a, et seq. Kayenta Complex Permanent Program Permit AZ-0001E Life-of-Mine Plan Revision. Submitted to OSMRE May 1, 2012. Last updated March 27, 2015.

Peabody Western Coal Company (PWCC). 2012b. 2011 Seepage Monitoring and Management Report, NPDES Permit No. NN0022179. Peabody Western Coal Company – Kayenta Complex. May 9, 2012. Peabody Western Coal Company. Kayenta, Arizona.

Peabody Western Coal Company (PWCC). 2011. 2010 Reclamation Status and Monitoring Report for the Black Mesa and Kayenta Mines. Report to the Office of Surface Mining, Reclamation, and Enforcement, Western Division, Denver, Colorado. May 13, 2011. Peabody Western Coal Company, Kayenta, Arizona.

Peabody Western Coal Company (PWCC). 2010. 2009 Reclamation Status and Monitoring Report for the Black Mesa and Kayenta Mines. Report to the Office of Surface Mining, Reclamation, and Enforcement, Western Division, Denver, Colorado. May 24, 2010. Peabody Western Coal Company, Kayenta, Arizona.

Peabody Western Coal Company (PWCC). 2009. 2008 Reclamation Status and Monitoring Report for the Black Mesa and Kayenta Mines. Report to the Office of Surface Mining, Reclamation, and Enforcement, Western Division, Denver, Colorado. May 28, 2009. Peabody Western Coal Company, Kayenta, Arizona.

Peirce, H. W., S. B. Keith, and J. C. Wilt. 1970. Coal, Oil, Natural Gas, Helium, and Uranium in Arizona. Bulletin 182. The Arizona Bureau of Mines. University of Arizona, Tucson.

Raisbeck, M. F., S. L. Riker, C. M. Tate, R. Jackson, M. A. Smith, K. J. Reddy, and J. R. Zygmunt. 2008. Water Quality for Wyoming Livestock and Wildlife. A review of the literature pertaining to health effects of inorganic contaminants. B-1183. University of Wyoming Department of Veterinary Sciences, University of Wyoming Department of Renewable Resources, Wyoming Game and Fish Department, Wyoming Department of Environmental Quality. University of Wyoming, Laramie. Internet website: http://www.uwyo.edu/uwe/pubs/b1183/index.html. Accessed June 25, 2015.

Ramboll Environ. 2016a. DRAFT FINAL NGS Near-Field Ecological Risk Assessment Environmental Impact Statement Final Report for the Navajo Generating Station. Version 2. March 2016.

Ramboll Environ. 2016b. DRAFT FINAL NGS San Juan River Ecological Risk Assessment Environmental Impact Statement Summary Report for the Navajo Generating Station. April 2016.

Ramboll Environ. 2016c. DRAFT FINAL NGS Gap Region Ecological Risk Assessment Environmental Impact Statement Final Report for the Navajo Generating Station. March 2016.

Ramboll Environ. 2016d. DRAFT FINAL Ecological Risk Assessment, Environmental Impact Statement Ecological Risk Assessment Report for the Kayenta Mine Complex. April 2016.

Ramboll Environ 2016e. Final NGS Sampling Investigation Report, Salt River Project – Navajo Generating Station. Revision 1, December 2015.

Redsteer, M. H. 2012. Increasing Vulnerability to Drought and Climate Change on the Navajo Nation: Current Conditions & Accounts of Changes during the Last 100 Years. U. S. Geological Survey presentation to the Navajo Nation Department of Agriculture, Resources and Development Committee, Public Meetings of July 12, 13, and 14, 2012, held at the Fire Rock Casino, Church Rock, New Mexico. Navajo Nation Department of Information Technology.

Redsteer, M. H., K. B. Kelley, H. Harris, and D. Block. 2010. Disaster Risk Assessment Study: Recent Drought on the Navajo Nation, Southwestern United States. Global Assessment Report of Disaster Risk Reduction 2011, Annexes and Papers, Chapter 3. United Nations Office for Disaster Risk Reduction, in cooperation with the USGS. Geneva, Switzerland. Internet website: http://www.preventionweb.net/english/hyogo/gar/2011/en/what/drought.html. Accessed July 2, 2015.

Repenning, C. A. and H. G. Page. 1956. Late Cretaceous Stratigraphy of Black Mesa, Navajo and Hopi Indian Reservations, Arizona. Bulletin of the American Association of Petroleum Geologists 40(2):255-294. American Association of Petroleum Geologists, Tulsa, Oklahoma. Internet website: http://archives.datapages.com/data/bulletns/1953-56/data/pg/0040/0002/0250/0255.htm?q=%2ByearSort%3A%5B1956+TO+1956%5D . Accessed January 22, 2015.

Schonauer, K. T., R. J. Hart, and R. C. Antweiler. 2014. The Presence and Distribution of Polycyclic Aromatic Hydrocarbons and Inorganic Elements in Water and Lakebed Materials and the Potential for Bioconcentration in Biota at Established Sampling Sites on Lake Powell, Utah and Arizona. U.S. Geological Survey Open-File Report 2013-1299, 28 p. Internet website: http://dx.doi.org/10.3133/ofr20131299. Accessed November 25, 2015.

Sigler, W. A. and K. Kleehammer. 2013. Suitability of Water for Livestock. Montana State University Extension Water Quality Program, Department of Land Resources and Environmental Sciences.

Tetra Tech. 2016. Personal communications regarding continuing discussions and clarifications of modeling approaches and outputs for the Three-Dimensional Flow Model of the D- and N-Aquifers with the PWCC/Tetra Tech groundwater modeling team. January to May 2016.

Tetra Tech. 2015a. Predicted Effects of Pumping by PWCC under the Proposed Mine Plan Revision. Prepared for Peabody Western Coal Company. Prepared by Tetra Tech, Inc. Louisville, Colorado. October 2015. 223 pgs.

Tetra Tech. 2015b. Personal communications regarding output files from the Three-Dimensional Flow Model of the D- and N-Aquifers, with the PWCC/Tetra Tech groundwater modeling team. January to December 2015.

Tetra Tech. 2014. Update of Peabody Western Coal Company's Groundwater Flow Model of the N and D Aquifers, Northeastern Arizona. Version 1.0. Tetra Tech, Inc. January 15, 2014.

Tetra Tech. 2011. *Final Consolidated Report, Source Water Assessment for Communities and Villages of the Hopi Reservation.* 1,285 pages. Prepared for: Hopi Tribe Water Resources Program, Flagstaff, Arizona. Prepared by: Tetra Tech, EMI, Denver, CO. January 2011.

Tinger, J. A. 2015. Personal communication regarding seep management and NPDES permit documentation for Peabody Western Coal Company, Kayenta operations between J. Tinger, Wastewater Enforcement staff, USEPA, Sacramento, California and J. Burrell, AECOM,. February 6, 2015.

Truini, M. and S. A. Longsworth. 2003. Hydrogeology of the D Aquifer and Movement and Ages of Ground Water Determined from Geochemical and Isotopic Analyses, Black Mesa Area, Northeastern Arizona. Water-Resources Investigations Report 03-4189_Version 1.1. Prepared in cooperation with the Bureau of Indian Affairs. U.S. Geological Survey, Tucson, Arizona.

Truini, M. and J. P. Macy. 2006. Lithology and Thickness of the Carmel Formation as related to Leakage between the D and N Aquifers, Black Mesa, Arizona. U.S. Geological Survey Scientific Investigations Report 2005-5187, 7 p., 1 pl.

U.S. Army Corps of Engineers (USACE). 2012. Nationwide Permit 12. Utility Line Activities. Effective date March 19, 2012. NWP Final Notice, 77 FR 10184.

U.S. Bureau of Reclamation (Reclamation). 2015a. Glen Canyon Dam/Lake Powell, Current Status. Upper Colorado Region, Water Resources Group. Internet website: http://www.usbr.gov/uc/water/crsp/cs/gcd.html. Accessed June 11, 2015.

U.S. Bureau of Reclamation (Reclamation). 2015b. Glen Canyon Dam Long-Term Experimental and Management Plan (LTEMP), Environmental Impact Statement. Public Draft, Executive Summary. U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, and National Park Service, Intermountain Region. December 2015.

U.S. Bureau of Reclamation (Reclamation). 2009. Record of Decision for the Navajo-Gallup Water Supply Project Planning Report and Final Environmental Impact Statement. September 2009. USDI Bureau of Reclamation, Upper Colorado Region. Internet website: http://www.usbr.gov/uc/rm/navajo/nav-gallup/ Accessed May 2, 2016.

U.S. Bureau of Reclamation (Reclamation). 2007. Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead. Final Environmental Impact Statement. Appendix A, Attachment B. October 2007. Boulder City, Nevada. Internet website: http://www.usbr.gov/lc/region/programs/strategies/FEIS/. Accessed May 13, 2016.

U.S. Environmental Protection Agency (USEPA). 2015. National Pollutant Discharge Elimination System (NPDES) Multi Sector General Permit for Stormwater Discharges associated with Industrial Activity (MSGP). Effective June 4, 2015. Internet website: http://www.epa.gov/sites/production/files/2015-10/documents/msgp2015_parts1-7.pdf. Accessed June 28, 2015.

U.S. Environmental Protection Agency (USEPA). 2010. Fact Sheet. Peabody Western Coal Company – Black Mesa Complex. NPDES Permit No. NN0022179. Final Permit, 2010. U.S. Environmental Protection Agency, Region 9, Water Program, San Francisco, California. Internet website: http://www3.epa.gov/region09/water/npdes/pdf/navajo/PeabodyWesternCoal-FactSheetFnl-2010.pdf Accessed March 7, 2013.

U.S. Geological Survey (USGS). 2015. USGS Water Data for the Nation. Internet website: http://nwis.waterdata.usgs.gov/nwis/. Accessed January through August 2015.

U.S. Geological Survey (USGS)–National Water Information Service (USGS-NWIS). 2015. Flow or Water Level Data, and Water Quality Data for Surface Water Streams and Rivers, and Groundwater Springs and Wells. Internet website: http://waterdata.usgs.gov/az/nwis/sw, http://waterdata.usgs.gov/az/nwis/gw, http://waterdata.usgs.gov/ut/nwis/sw. Accessed from December 23, 2014 through August 2015.

Utah Department of Environmental Quality, Division of Water Quality (UDEQ-DWR). 2015. Ambient Water Quality Monitoring System. Salt Lake City, Utah. Internet website: http://www.deq.utah.gov/Compliance/monitoring/water/Data.htm . Accessed December 2, 2015.

Utah Department of Environmental Quality. Division of Water Quality (DWR). 2016. Standards of Water Quality for the State. Utah Administrative Code R317-2, effective June 1, 2016. Utah Department of Environmental Quality, Division of Water Quality, Salt Lake City, Utah. Internet website: http://www.rules.utah.gov/publicat/code/r317/r317-002.htm. Accessed July 16, 2016.

Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, S. Doney, R. Feely, P. Hennon, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville. 2014: Chapter 2: Our Changing Climate. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Editors, U.S. Global Change Research Program, 19-67.7930/J0KW5CXT.

Washington County Water Conservancy District. 2016. Lake Powell Pipeline Fact Sheet. Internet website: http://www.wcwcd.org/projects/lake-powell-pipeline/. Accessed May 23, 2016.

Western Regional Climate Center. 2015a. Precipitation Data Summaries for selected Arizona climate stations. Internet website: http://www.wrcc.dri.edu/summary/Climsmaz.html. Accessed August 18, 2014 through June 16, 2015.

Western Regional Climate Center. 2015b. Evaporation Data Summaries for Arizona. Internet website: http://www.wrcc.dri.edu/htmlfiles/westevap.final.html#ARIZONA. Accessed January 7, 2015.

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